5 Mai

COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

COMITÉ DE RÉDACTION

A. Borissiak, de l'Académie, A. Fersman, de l'Académie, A. Frumkin, de l'Académie, A. Richter, de l'Académie, S. Wawilow, de l'Académie

NOUVELLE SÉRIE

6-me année

Paraissant tous les dix jours

1938

VOLUME XIX, № 4

TABLE DES MATIÈRES

Pages

MATHÉMATIQUES

A. Alexandrov. Ein allgemeiner Eindeutigkeitssatz für geschlossene Flächen 227
N. Lusin, de l'Académie. Sur l'existence des surfaces algébriques sans réseau conjugué persistant. III, IV 231

PHYSIQUE

J. Khurgin. On the Upper Limit of Ion Energy Obtainable by Means of the Cyclotron 237
L. V. Grošev and **I. M. Frank.** Nuclear Impulse in Pair Creation . . . 239
V. Černiaev. Influence of Noble Gases on the Intensity of Lines of Hydrogen and Deuterium Balmer Series 243
I. K. Kikoin and **S. V. Goobar.** Gyromagnetic Effect in Superconductors 249

GÉOCHIMIE

I. D. Borneman-Starinkevitch. On Some Isomorphic Substitutions in Apatite 253
S. A. Borovick and **S. K. Kalinin.** Spectroscopical Analysis of the Products of Lead and Zinc Plants 257

GÉOLOGIE

A. V. Peive. On the Carboniferous Gypsums and the Red Devonian Sandstones of Tyan-Shan 259
L. Lungershausen. The Terraces of the Dniester 261
L. Lungershausen. Pliocene Hydrography of the South Ukraine 265

MINÉRALOGIE

A. E. Fersman, Member of the Academy. On the Number of Mineral Species 269
L. A. Kossoy. Intergrowth of Quartz and Feldspars from the Pegmatite Veins of Karelia 273

GÉNÉTIQUE

R. A. Masing. Genetical and Cytological Analysis of Lethals in *Drosophila* Arisen in Nature 277
L. N. Kokhanovskaya. Physiological Sterility in the Cultivated Columbian Potato *Solanum Rybinii* Juz. and Buk. 281
V. I. Patrushev. Inheritance of Biochemical Characters in Animals in Connection with Growth. III. On Some Indices of the Blood Composition of the Hybrids between Bactrian Camels and Dromedaries in Connection with Heterosis 285
V. I. Patrushev. Inheritance of Biochemical Characters in Animals in Connection with Growth. IV. Differences in Composition of Blood in Horses, Asses and Mules 291
G. S. Žukova. Influence of Light upon the Development of Pollen of Barley 297
N. N. Medvedev. Contributory Effect of Heat with Irradiation in the Production of Mutations 301

PHYSIOLOGIE VÉGÉTALE

M. Ch. Čajlachjan and **L. P. Ždanova.** The Rôle of Growth Hormones in Form-Building Processes. III. Effect of Heteroauxin Treatment of Seeds upon Growth and Development of Plants 303
S. M. Mashtakov. Qualitative Changes of Rubber and Resins in Kok-Saghyz Roots in the Course of the Plant Development 307
A. A. Nichiporovich and **V. N. Bourovaya.** Rubber Accumulation in Kok-Saghyz as a Function of its Biological Maturing Process 311

PHYSIOLOGIE ANIMALE

Ch. S. Koshtoyanz. On the Mechanism of the Formation of Chemical Mediators of Nerve Impulses 315

ZOOLOGIE

Z. G. Sčedrina. On the Distribution of Foraminifera in the Kara Sea . . . 319
J. Rall. Notes on the Ecology of *Diplomesodon pulchellum pulchellum* Licht. in the Volga-Ural Sandy Regions 323

ZOOLOGIE EXPÉRIMENTALE

N. L. Gerbilsky. Effet des injections crâniennes de suspension d'hypophyse chez les téléostéens 327
N. L. Gerbilsky. L'influence de l'agent gonadotrope de l'hypophyse sur l'état de la fraieson chez l'*Acipenser stellatus* 333

Rédacteur en chef A. Fersman. Rédacteur S. Bernstein.

En composition 15/IV 1938. En impression 22/V 1938. Nombre de feuilles d'impression 7. Nombre de caractères par feuille d'impression 65.000. Pages 225—336. Format du papier 72 × 110 cm. Tirage 1 300. Moscou. B—46135. Numéro d'édition 787. Numéro typographique 605.

Imprimerie № 16, Moscou, Trekhproudnij péréoulok, 9.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

MATHEMATIK

EIN ALLGEMEINER EINDEUTIGKEITSSATZ FÜR GESCHLOSSENE FLÄCHEN

Von A. ALEXANDROV

(Vorgelegt von I. M. Vinogradow, Mitglied der Akademie, d. 5. III. 1938)

Es sei $H(\bar{u})$ eine Funktion des Vektors $\bar{u}$ im ganzen dreidimensionalen Raume, positiv homogen vom ersten Grade. Es bezeichne H die Enveloppe der Schar von Ebenen $\bar{u}\bar{x} = H(\bar{u})$. Die Eigenwerte R_1, R_2 des zweiten Differentials $d^2H(\bar{u})$, die für Einheitsvektoren $\bar{u}$ genommen sind, stellen die Hauptkrümmungsradien von H dar.

Lehrsatz I. Es sei $f(R_1, R_2; \bar{n})$ eine stückweise analytische Funktion von R_1, R_2 und dem Punkte $\bar{n}$ auf der Einheitskugel, die in einem Gebiete D definiert ist, wo $R_1 \geqslant R_2$ ist. Es sei ferner $\frac{\partial f}{\partial R_1} \cdot \frac{\partial f}{\partial R_2} > 0$. Die Fläche H, für welche die Funktion $f(R_1, R_2; \bar{n})$ der Hauptkrümmungsradien R_1, R_2 auf der ganzen Einheitskugel gegeben ist, ist bis auf Translation eindeutig bestimmt.

Kommen konvexe Flächen in Betracht, so ist es zweckmässig das Gebiet D durch die Bedingung $R_1 \geqslant R_2 > 0$ zu definieren. Dann ist es klar, dass unser Satz die bekannten Sätze von Minkowski und Christoffel einschliesst.

Lehrsatz II. Die Funktion $f(R_1, R_2; \bar{n})$ genügt den Bedingungen von Lehrsatz I. Falls $f(R_1, R_2; \bar{n})$ für eine deformierbare Fläche H stationär bleibt, so erfährt H nur eine infinitesimale Translation.

Wir verzichten auf eine besondere Darlegung des Beweises für Lehrsatz II, da er demjenigen von Lehrsatz I ganz ähnlich ist.

Beweis von Lehrsatz I. Es seien $H'(\bar{u})$ und $H''(\bar{u})$ zwei Funktionen, für welche die Funktionen $f(R_1, R_2; \bar{n}) = g(\bar{n})$ übereinstimmen. Es sei ferner

$$H'(\bar{u}) - H''(\bar{u}) = Z(\bar{u}).$$

Wir wollen zeigen, dass überall $d^2Z(\bar{u}) = 0$ ist, so dass $Z(\bar{u}) = \bar{a}\bar{u}$ sein muss. Grösserer Bestimmtheit halber werden wir annehmen, dass

$$\frac{\partial t}{\partial R_1}, \quad \frac{\partial t}{\partial R_2} > 0 \qquad (1)$$

sind.

1. Bei beliebigen $\bar{u}$ nimmt die Form $d^2Z(\bar{u})$ entweder Werte von verschiedenen Vorzeichen an, oder verschwindet identisch.

Aus Bedingung (1) ersieht man, dass bei

$$f(R_1', R_2'; \bar{n}) = f(R_1'', R_2''; \bar{n}) \tag{2}$$

$R_1' - R_1''$, $R_2' - R_2''$ verschiedene Vorzeichen haben, oder beide verschwinden. In Anbetracht der Bedeutung von R_1, R_2 und unter Bezugnahme darauf, dass

$$d^2Z(\bar{u}) = d^2H'(\bar{u}) - d^2H''(\bar{u}), \tag{3}$$

sehen wir, dass unsere Behauptung richtig ist.

2. Die Gleichung

$$f(R_1, R_2; \bar{n}) = g(\bar{n}) \tag{4}$$

stellt für die Funktion $H(\bar{u})$ eine partielle Differentialgleichung zweiter Ordnung dar, wie aus der Bedeutung von R_1, R_2 klar ist. Bei beliebiger Auswahl der Parameter u, v in der Umgebung eines beliebigen Punktes auf der Einheitskugel ist die Gleichung:

$$f(R_1, R_2; \bar{n}) = F(H_{uu}, H_{uv}, H_{vv}, H_u, H_v, H, u, v) = g(\bar{n}), \tag{5}$$

nach H_{uu} auflösbar.

Führen wir als Veränderliche $r = |\bar{u}|$ und die Parameter u, v ein, so dass

$$H(\bar{u}) = rH(u, v) \tag{6}$$

ist, dann wird, falls $|\bar{u}| = r = 1$,

$$d^2H(\bar{u}) = H_{uu}du^2 + 2H_{uv}dudv + H_{vv}dv^2 + 2(H_u du + H_v dv)dr. \tag{7}$$

Bei wachsendem H_{uu} nehmen die Eigenwerte der Form (7) nicht ab und mindestens einer von ihnen wächst. Also ist zum Beispiel:

$$\frac{\partial R_1}{\partial H_{uu}} > 0, \quad \frac{\partial R_2}{\partial H_{uu}} \geqslant 0. \tag{8}$$

Aus (8) und (1) ergibt sich:

$$\frac{\partial F}{\partial H_{uu}} = \frac{\partial F}{\partial R_1}\frac{\partial R_1}{\partial H_{uu}} + \frac{\partial F}{\partial R_2}\frac{\partial R_2}{\partial H_{uu}} > 0. \tag{9}$$

Auf Grund dieser Ungleichung und des bekannten Theorems über die impliziten Funktionen schliessen wir, dass in der Umgebung der Werte H_{uu}, H_{uv}, ..., H, u, v, die der Gleichung (5) genügen, diese Gleichung nach H_{uu} eindeutig auflösbar ist. Also ist

$$H_{uu} = \Phi(H_{uv}, H_{vv}, H_u, H_v, H, u, v). \tag{10}$$

3. $Z(\bar{u}) = H'(\bar{u}) - H''(\bar{u})$ ist stückweise analytisch. In jedem Gebiete auf der Einheitskugel, wo $Z(\bar{u})$ analytisch ist, verschwindet $d^2Z(\bar{u})$ entweder überall, oder auf einigen Linien, oder in isolierten Punkten, wie aus dem Weierstrass'schen Satz über die impliziten analytischen Funktionen folgt.

Falls $d^2Z(\bar{u})=0$ auf einer Linie (auf der Kugel) gilt, so ist $Z(\bar{u})=\bar{a}\bar{u}$.

Es sei C eine Linie, auf der $d^2H'=d^2H''$ ist. Es ist möglich eine solche Translation der Fläche H'' auszuführen, dass $dH'=dH''$ und $H'=H''$ auf der ganzen C wird. Nehmen wir C als Parameterlinie $u=0$ an, so sehen wir aus Paragraphen 2, dass $H'(u, v)$ und $H''(u, v)$ einer und derselben Gleichung (10) mit denselben Anfangsbedingungen auf C genügen. Also ist kraft des Theorems von Cauchy $H'(u, v)=H''(u, v)$ in der Umgebung von C.

Es sei $d^2Z=0$ in einem Gebiete, wo Z analytisch ist, dann lässt sich, auf Grund des soeben Bewiesenen, das Verschwinden von d^2Z über die Grenze dieses Gebietes hinaus erweitern.

4. Es bleibt der Fall des Verschwindens von d^2Z in isolierten Punkten zu erleidigen. Zu diesem Zwecke betrachten wir die Fläche Z—die Enveloppe der Schar von Ebenen $\bar{u}\bar{x}=Z(\bar{u})$. Diese Fläche ist begrenzt, also hat sie Stützebenen beliebiger Richtung. Da aber in den Punkten, wo $d^2Z\neq 0$, die Hauptkrümmungsradien von Z verschiedene Vorzeichen haben, so gehen durch solche Punkte keine Stützebenen. Wir werden zeigen, dass durch jeden Punkt, wo $d^2Z=0$ ist, nicht mehr als eine einzige Stützebene gehen kann. Da aber solche Punkte isoliert sind, so widerspricht das dem Vorhandensein von Stützebenen beliebiger Richtung.

5. Es sei $\bar{n}_0$ ein Punkt auf der Einheitskugel, wo $d^2Z=0$ ist, und $U(\bar{n}_0)$ die Umgebung von $\bar{n}_0$, die keine anderen Punkte dieser Art enthält; sei O der $\bar{n}_0$ entsprechende Punkt auf Z, und sei S das Stück von Z, welches der Umgebung $U(\bar{n}_0)$ entspricht.

Wir legen durch O eine Ebenen E_0 mit der Normalen $\bar{n}_0$ und durch einen anderen Punkt von S eine Gerade a, die keiner der Tangentialebenen von S parallel ist. Wollen wir a parallel verschieben, so dass ihr Schnittpunkt mit E_0 einen Kreis C um O beschreibt. Die Gerade a kann die Grenze von S überschreiten. Geschähe dieses bei beliebig kleinem C und einer beliebig kleinen Umgebung $U(\bar{n}_0)$, so wäre O die Projektion in der Richtung a der Punkte der Grenzen von diesen Umgebungen entsprechenden Flächen S.

S wurde also eine zu a parallele Strecke enthalten, was unmöglich ist, da S keine zu a parallel Tangentialebene hat. Wird also C genügend klein, so wird a immer durch S gehen. Folglich muss jede zu a parallel durch O geführte Ebene die Fläche S schneiden. Da aber $U(\bar{n}_0)$ beliebig klein ist, so sehen wir, dass nur die Ebene mit der Normalen $\bar{n}_0$ die Stützebene an Z im Punkte O sein kann.

Es lässt sich übrigens zeigen, dass auch diese Ebene die Fläche S schneiden muss.

Staatsuniversität.
Leningrad.

Eingegangen
d. 9. III. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

MATHÉMATIQUES

SUR L'EXISTENCE DES SURFACES ALGÉBRIQUES SANS RÉSEAU CONJUGUÉ PERSISTANT. III, IV

Par N. LUSIN, de l'Académie

3. Structure des équations définissant les réseaux conjugués persistants. Je renvoie le lecteur à mes Notes précédentes. L'équation (I), $\Phi=0$, ne contient aucune dérivée partielle de ψ; elle contient les dérivées secondes de φ toutes renfermées dans $\Delta_\varphi\Delta_\varphi\varphi$; elle contient les dérivées troisièmes des fonctions E, F, G toutes renfermées dans $\Delta_\varphi K$. L'équation (III), $\Phi_2=0$, subit les mêmes observations, le rôle des fonctions φ et ψ étant changé. L'équation (II), $\Phi_1=0$, contient les dérivées secondes des fonctions φ et ψ toutes renfermées dans la différence $\Delta_\psi\Delta_\psi\varphi-\Delta_\varphi\Delta_\varphi\psi$ puisque, d'après la formule (10), la différence $\Delta_\theta\Delta_\gamma z-\Delta_\gamma\Delta_\theta z$ ne contient que les dérivées du premier ordre de z; elle contient les dérivées quatrièmes des fonctions E, F, G toutes renfermées dans la somme $\Delta_\varphi\Delta_\psi K+\Delta_\psi\Delta_\varphi K$.

Mais on a évidemment:

$$\Delta_\varphi\Delta_\varphi\varphi=\frac{\partial^2\varphi}{\partial v^2}+2\varphi\frac{\partial^2\varphi}{\partial u\partial v}+\varphi^2\frac{\partial^2\varphi}{\partial u^2}+\ldots;$$

$$\Delta_\psi\Delta_\psi\psi=\frac{\partial^2\psi}{\partial v^2}+2\psi\frac{\partial^2\psi}{\partial u\partial v}+\psi^2\frac{\partial^2\psi}{\partial u^2}+\ldots; \tag{11}$$

$$\Delta_\psi\Delta_\psi\varphi-\Delta_\varphi\Delta_\varphi\psi=\frac{\partial^2\varphi}{\partial v^2}+2\psi\frac{\partial^2\varphi}{\partial u\partial v}+\psi^2\frac{\partial^2\varphi}{\partial u^2}-$$

$$-\left(\frac{\partial^2\psi}{\partial v^2}+2\varphi\frac{\partial^2\psi}{\partial u\partial v}+\varphi^2\frac{\partial^2\psi}{\partial u^2}\right)+\ldots; \tag{12}$$

$$K=M\cdot\left(\frac{\partial^2E}{\partial v^2}-\frac{\partial^2F}{\partial u\partial v}+\frac{\partial^2G}{\partial u^2}\right)+\ldots;$$

où $M=-\frac{1}{2\sqrt{EG-F^2}}$ et où nous ne retenons que les dérivées du second ordre. Si donc on ne conserve que les dérivées supérieures des fonctions E, F, G et si l'on omet les dérivées mixtes, on obtient

$$\Delta_\varphi\Delta_\psi K+\Delta_\psi\Delta_\varphi K=2M\cdot\left(\frac{\partial^4E}{\partial v^4}+\varphi\psi\frac{\partial^4G}{\partial u^4}\right)+\ldots \tag{13}$$

4. Solution des problèmes posés. Les trois relations $\Phi=0$, $\Phi_1=0, \Phi_2=0$ auxquelles sont assujetties deux fonctions φ et ψ peuvent être régardées comme formant un système $(\sum)$ de trois équations aux dérivées partielles qui définit les trois fonctions inconnues: φ, ψ et l'une des fonctions E, F et G prise ad libitum. Cette remarque, qu'on doit à S. Finikoff, suffit pour démontrer en toute rigueur l'existence des surfaces analytiques S sans réseau conjugué persistant. Supposons, en effet, que l'on veuille calculer les fonctions φ, ψ et E en choisissant F et G

comme fonctions analytiques quelconques données. Si l'on porte ces valeurs de F et de G dans les équations

$$\Phi=0, \quad \Phi_1=0, \quad \Phi_2=0 \qquad (\Sigma)$$

et si l'on remarque que ce système (Σ), regardé comme définissant les fonctions inconnues φ, ψ et E, d'après les formules (11), (12) et (13), se réduise aussitôt à la forme normale de Cauchy-Kowalewska:

$$\frac{\partial^2\varphi}{\partial v^2}=\Phi^*, \quad \frac{\partial^4 E}{\partial v^4}=\Phi_1^*, \quad \frac{\partial^2\psi}{\partial v^2}=\Phi_2^* \qquad (\Sigma^*)$$

on trouvera, par l'application du théorème que j'ai démontré dans une Note récente [C. R. Acad. Sci. URSS, XVIII, № 8 (1938)], un polynôme $P(u, v)$ en u, v à coefficients entiers tel que l'on ait rigoureusement $|E-P(u, v)|>0$ dans tout domaine D à deux dimensions situé dans le plan des u et v, et ceci quelles que soient les fonctions analytiques φ, ψ et E vérifiant les équations du système (Σ). On conclut immédiatement de là que si l'on porte le polynôme $P(u, v)$ comme la valeur de E, $E=P(u, v)$, dans les équations $\Phi=0$, $\Phi_1=0$ et $\Phi_2=0$, le système (Σ) de trois équations ainsi obtenu ne peut jamais être satisfait par aucune couple φ, ψ de deux fonctions analytiques. C'est un cas d'incompatibilité assurée du système (Σ) des équations $\Phi=0$, $\Phi_1=0$, $\Phi_2=0$.

Nous sommes ainsi amenés à cette proposition rigoureusement démontrée:

Théorème I. *Etant données deux fonctions analytiques $F(u, v)$ et $G(u, v)$* quelconques *de deux variables indépendantes u et v, on peut trouver un polynôme $E(u, v)$ en u, v à coefficients entiers tel que* toute *surface analytique S ayant la forme $ds^2=E\,du^2+2F\,du\,dv+G\,dv^2$ pour élément linéaire soit une surface sans réseau conjugué persistant.*

Pour reconnaître s'il y a de telles surfaces algébriques, nous avons besoin d'entrer dans les détails du raisonnement de ma Note indiquée. Tout d'abord, il importe de remarquer que la fonction $\mathfrak{F}(t_1, t_2, \ldots, t_s)$ a été formée là au moyen d'une élimination algébrique. Il en résulte qu'ici, dans l'étude du système (Σ^*), la fonction $\mathfrak{F}(t_1, t_2, \ldots, t_s)$ des variables indépendantes $t_1, t_2, \ldots, t_s$ holomorphe et non identiquement nulle dépend d'une manière analytique des seules lettres F et G et leurs dérivées partielles jusqu'à l'ordre p déterminé. D'autre part, si nous remplaçons les variables $t_1, t_2, \ldots, t_s$ par les dérivées partielles déterminées $\frac{\partial^{k_1}E}{\partial v^{k_1}}, \frac{\partial^{k_2}E}{\partial v^{k_2}}, \ldots, \frac{\partial^{k_s}E}{\partial v^{k_s}}$ de la fonction E qui satisfait au système (Σ^*)prises par rapport à v, nous obtiendrons sûrement une expression identiquement nulle.

Cela posé, soient $F(u, v)$ et $G(u, v)$ des *polynômes* en u, v quelconques donnés. Nous commençons par chercher, d'après le théorème de ma Note indiquée, un polynôme $E(u, v)$ en u, v tel que l'expression $\mathfrak{F}\left(\frac{\partial^{k_1}E}{\partial v^{k_1}}, \frac{\partial^{k_2}E}{\partial v^{k_2}}, \ldots, \frac{\partial^{k_s}E}{\partial v^{k_s}}\right)$ soit holomorphe et non nulle pour $u=u^0$, $v=v^0$. Or, on sait que le système de trois équations aux dérivées partielles:

$$E=\left(\frac{\partial x}{\partial u}\right)^2+\left(\frac{\partial y}{\partial u}\right)^2+\left(\frac{\partial z}{\partial u}\right)^2, \quad F=\frac{\partial x}{\partial u}\frac{\partial x}{\partial v}+\frac{\partial y}{\partial u}\frac{\partial y}{\partial v}+$$
$$+\frac{\partial z}{\partial u}\frac{\partial z}{\partial v}, \quad G=\left(\frac{\partial x}{\partial v}\right)^2+\left(\frac{\partial y}{\partial v}\right)^2+\left(\frac{\partial z}{\partial v}\right)^2, \qquad (14)$$

contenant les coordonnées rectangulaires x, y, z d'un point de la surface S traitées comme des fonctions inconnues admet une solution $x(u,v)$, $y(u,v)$, $z(u,v)$ régulière au voisinage de $u=u^0$, $v=v^0$. Par conséquent, lorsque, dans les développements de Taylor des x, y, z, on s'arrête aux termes de rang m suffisamment élevé, on obtient trois polynômes $P(u,v)$, $Q(u,v)$ et $R(u,v)$ en u, v tels que si nous remplaçons dans l'expression $\mathfrak{F}\left(\frac{\partial^{k_1}E}{\partial v^{k_1}}, \frac{\partial^{k_s}E}{\partial v^{k_s}}, \ldots, \frac{\partial^{k_s}E}{\partial v^{k_s}}\right)$ les E, F et G par les expressions (14) en coordonnées rectangulaires x, y, z et ensuite les x, y, z par les polynômes correspondants $P(u,v)$, $Q(u,v)$, $R(u,v)$ l'expression finale $\mathfrak{F}$ soit holomorphe et encore non nulle pour le point u^0, v^0*. On déduit immédiatement de là que la surface algébrique S définie par les équations:

$$x=P(u,v),\quad y=Q(u,v),\quad z=R(u,v),$$

ne peut admettre aucun réseau conjugué persistant.

En définitive, nous pouvons compléter ainsi la proposition précédente:

Théorème II. *On peut trouver trois polynômes $P(u,v)$, $Q(u,v)$, $R(u,v)$ en u, v tels que la surface algébrique S définie par les trois équations $x=P(u,v)$, $y=Q(u,v)$, $z=R(u,v)$ soit une surface sans réseau conjugué persistant* **.

Pour aller plus loin, revenons au système $(\sum)$ des équations $\Phi=0$, $\Phi_1=0$, $\Phi_2=0$ regardé comme définissant deux fonctions inconnues φ et ψ. Nous considérons ici les fonctions E, F et G comme données. Voici maintenant les faits analytiques précis qui peuvent être observés à l'égard de ce système***:

1) toute dérivée partielle de φ et de ψ peut être calculée en fonction rationnelle des seuls douze quantités:

$$\varphi, \frac{\partial\varphi}{\partial u}, \frac{\partial\varphi}{\partial v}, \frac{\partial^2\varphi}{\partial u^2}, \frac{\partial^3\varphi}{\partial u^3}, \quad \psi, \frac{\partial\psi}{\partial u}, \frac{\partial\psi}{\partial v}, \frac{\partial^2\psi}{\partial u^2}, \frac{\partial^2\psi}{\partial u\partial v}, \frac{\partial^3\psi}{\partial u^3}, \frac{\partial^4\psi}{\partial u^4},$$

traitées comme des variables indépendantes (les fonctions données E, F, G et leurs dérivées partielles peuvent y figurer);

2) la solution la plus générale φ, ψ du système $(\sum)$ (s'il existe des solutions de ce système) peut se mettre sous la forme:

$$\varphi=H(u, v, C_1, C_2, \ldots, C_{12}),$$
$$\psi=H_1(u, v, C_1, C_2, \ldots, C_{12}),$$

de deux fonctions analytiques H et H_1 de deux variables indépendantes u, v et de douze paramètres $C_1, C_2, \ldots, C_{12}$ dont les uns peuvent dépendre des autres.

---

* On reconnaît ici le principe de la continuité appliqué d'une manière correcte.

** Depuis que ceci a été écrit, S. Finikoff a indiqué une autre voie pour arriver à cette proposition. Sa méthode part de même du théorème indiqué relatif aux systèmes d'équations aux dérivées partielles et ensuite fait l'emploi des équations dues à Gauss et à Darboux [1].

*** D'ailleurs, on peut regarder ces faits analytiques concernant le système particulier $(\sum)$ comme provenants d'une proposition générale relative aux systèmes d'équations simultanées aux dérivées partielles. La démonstration de cette proposition est trop longue pour mettre ici.

D'autre part, la détermination de la quantité $X=x^2$ (voir ma Note précédente) dépend du système complètement intégrable

$$\frac{\partial X}{\partial u}=A_0X^2+A_1X+A_2,\quad \frac{\partial X}{\partial v}=B_0X^2+B_1X+B_2, \tag{7}$$

où les A et les B sont des expressions différentielles dépendant des seules lettres $E, F, G, \varphi, \psi, a, b$ et de leurs dérivées partielles. Ici deux fonctions a et b sont liées par la relation (6): $ab=K/(\psi-\varphi)^2$ et, sans diminuer la généralité du raisonnement, nous pouvons poser $a=b=\sqrt{K}/(\psi-\varphi)$. L'application de la méthode de Mayer au système (7) nous amène à une et une seule équation de Riccati:

$$\frac{dX}{du}=(A_0^*+\lambda B_0^*)X^2+(A_1^*+\lambda B_1^*)X+(A_2^*+\lambda B_2^*), \tag{15}$$

en désignant par les A^* et les B^* ce que deviennent les A et les B correspondants quand on remplace v par λu, λ étant un paramètre. La solution générale X de l'équation (15) de Riccati, $X=C\alpha+\beta/C\gamma+1$ dans laquelle on remplace λ par $\frac{v}{u}$, est une fonction analytique de deux variables indépendantes u, v et de treize paramètres $C_1, C_2, \ldots, C_{12}, C$. La même conclusion a lieu pour le premier coefficient δ de la seconde forme quadratique $\delta du^2+2\delta' dudv+\delta'' dv^2$ d'une surface S ayant la forme donnée $ds^2=Edu^2+2Fdudv+Gdv^2$ pour élément linéaire et admettant sûrement un réseau conjugué persistant, puisque nous avons $\delta=ax+b/x$ (5), où $x^2=X$ et $a=b=\sqrt{K}/(\psi-\varphi)$. Donc, si nous posons $v=v^0$, δ devient une fonction analytique bien déterminée de la seule variable u et de treize paramètres $C_1, C_2, \ldots, C_{12}, C$

$$\delta=\omega(u, C_1, C_2, \ldots, C_{12}, C). \tag{16}$$

Or, une fonction analytique $A(z, C', C'', \ldots, C^{(k)})$ déterminée quelconque d'une variable indépendante z et de paramètres arbitraires $C', C'', \ldots$, en nombre fini k, ne peut jamais parcourir toutes les fonctions analytiques possibles $f(z)$ de la variable z lorsqu'on fait varier d'une manière arbitraire les valeurs numériques des paramètres $C', C'', \ldots$. C'est un fait analytique général qui n'est aucune conséquence directe du procédé diagonale de Cantor (si $k>1$), mais qui provient de ce que les coefficients du développement de Taylor:

$$A(z, C', C'', \ldots, C^{(k)})=A_0+\frac{A_1}{1!}(z-z_0)+\frac{A_2}{2!}(z-z_0)^2+\ldots+$$
$$+\frac{A_n}{n!}(z-z_0)^n+\ldots,$$

sont des fonctions analytiques déterminées des paramètres $C', C'', \ldots$. Il en résulte que tous les coefficients A_i sont des fonctions analytiques déterminées d'un nombre limité ($\leqslant k$) d'entre eux et, par suite, ne peuvent pas être pris arbitrairement. L'infinité des fonctions analytiques $f(z)$ qui échappent à la représentation $A(z, C', C'', \ldots, C^{(k)})$ est dépendante d'une fonction analytique arbitraire d'une variable indépendante.

En revenant à l'égalité (16), on a une infinité des fonctions analytiques $\Omega(u)$ dépendant d'une fonction analytique arbitraire qui échappent sûrement à la représentation $\omega(u, C_1, C_2, \ldots, C_{12}, C)$.

D'autre part, deux équations aux dérivées partielles de Codazzi:

$$\left.\begin{aligned}\frac{\partial\delta}{\partial v}-\frac{\partial\delta'}{\partial u}+p\delta+p'\delta'+p''\delta''=0,\\ \frac{\partial\delta''}{\partial u}-\frac{\partial\delta'}{\partial v}+q\delta+q'\delta'+q''\delta''=0,\end{aligned}\right\} \qquad (2)$$

et l'équation finie de Gauss:

$$\delta\delta''-\delta'^2=K, \qquad (3)$$

sont les seules auxquelles sont assujettis les coefficients δ, δ' et δ'' de la seconde forme quadratique. Puisque les équations (2) de Codazzi considérées comme définissant deux fonctions inconnues δ et δ', $\delta''=(K+\delta'^2)/\delta$, ont la forme normale de Cauchy-Kowalewska, toute surface $S(E, F, G, \delta, \delta', \delta'')$ ayant $ds^2=Edu^2+2Fdudv+Gdv^2$ pour élément linéaire est parfaitement déterminée par la connaissance seule de deux fonctions analytiques d'une variable indépendante, $\delta(u, v^0)$ et $\delta'(u, v^0)$, prises arbitrairement. Nous concluons de là que la surface S pour laquelle $\delta(u, v^0)=\Omega(u)$ ne peut admettre aucun réseau conjugué persistant. Nous sommes ainsi amenés à la proposition suivante:

Théorème III. *Étant donnée une surface analytique non développable S, il existe une infinité de surfaces analytiques S' dépendant de deux fonctions arbitraires d'une variable applicables sur S et privées totalement des réseaux conjugués persistants.*

Cela veut dire que presque toutes surfaces analytiques non développables S qui appartiennent à un élément linéaire donné ds n'ont aucun réseau conjugué persistant.

Une conséquence immédiate du théorème démontré est la suivante:

il existe une infinité de surfaces analytiques à courbure constante non nulle arbitraire qui n'ont aucun réseau conjugué persistant.

Cette proposition géométrique est en opposition évidente avec une proposition devenue classique (2), d'après laquelle toute surface minima possède nécessairement un réseau conjugué persistant.

Conclusion. Le problème de déformation à réseau conjugué persitant attirait constamment l'attention des géomètres de Moscou depuisi l'apparition des travaux de K. Peterson (1866). Nous avons examiné ic la généralité des considérations liées à ce problème, et nous avons constaté correctement que les surfaces admettant des réseaux conjugués persistants forment une famille très mince, ce qui ne diminue nullement l'importance de leurs recherches: parmi les courbes planes, les sections coniques ayant les propriétés si importantes forment aussi une famille très particulière.

De même, l'existence d'un réseau conjugué persistant est un phénomène géométrique très particulier et très rare. On peut croire qu'elle depend de la forme même, dans l'espace, d'une surface considérée S. Il paraît fort probable que si une surface analytique S est privée d'un réseau conjugué persistant, toute surface analytique S' suffisamment approchée de S l'est aussi.

5. Les conditions nécessaires et suffisantes. Mais les problèmes beaucoup plus difficiles sont les suivants:

Problème I. *Trouver les conditions nécessaires et suffisantes pour qu'un* élément linéaire donné $ds^2=Edu^2+2Fdudv+Gdv^2$ *admette un réseau conjugué persistant.*

Problème II. *Trouver les conditions nécessaires et suffisantes pour qu'une* surface donnée $S(E, F, G, \delta, \delta', \delta'')$ *admette un réseau conjugué persistant.*

Dans le premier cas, il s'agit de l'existence et de la réalisation effective d'un système complet des résultants $R\left(E, F, G, \frac{\partial E}{\partial u}, \ldots\right) = 0$, $R_1 = 0, \ldots$ qu'on prétend à avoir «en éliminant» φ et ψ entre les trois équations aux dérivées partielles

$$\Phi = 0 \text{ (I)}, \quad \Phi_1 = 0 \text{ (II)}, \quad \Phi_2 = 0 \text{ (III)}.$$

Dans le second cas, il s'agit d'un système analogue des résultants $R\left(E, F, G, \delta, \delta', \delta'', \frac{\partial E}{\partial u}, \ldots\right) = 0, R_1 = 0, \ldots$ qu'on veut obtenir «en éliminant» φ et ψ entre les équations $\Phi = 0$ (I), $\Phi_2 = 0$ (III) et l'équation finie (4) $\delta\varphi\psi + \delta'(\varphi + \psi) + \delta'' = 0$.

Il paraît qu'on a pris habitude de considérer ces deux problèmes comme débordants l'analyse contemporaine grâce à la complexité évidente des équations définissant les réseaux conjugués persistants.

Nous reviendrons à ces problèmes.

Manuscrit reçu
le 21. III. 1938.

LITTÉRATURE CITÉE

[1] Darboux, Leçons sur la théorie des surfaces, III, 251—255. [2] Peterson, Ueber Kurven und Flächen (1868).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

PHYSICS

ON THE UPPER LIMIT OF ION ENERGY OBTAINABLE BY MEANS OF THE CYCLOTRON

By J. KHURGIN

(Communicated by A. Joffe, Member of the Academy, 15. III. 1938)

At the present time the cyclotron, designed by Lawrence (1), is the most powerful apparatus for obtaining ions of high energies. It is based on the following principle. It is known that ions moving perpendicularly to a homogeneous magnetic field describe circles, and that when the ion energy is low as compared with m_0c^2, the period of revolution does not depend on energy and is equal to

$$T = \frac{2\pi mc}{eH}. \qquad (1)$$

Thus, a high frequency alternating voltage, of period $\tau = T$, may be applied for the multifold acceleration of ions. For instance, Lawrence and his collaborators (2), having an initial high frequency voltage of about 100 kV, obtained, for single-charged ions, a maximum energy of 6 MeV, i. e. they worked with a sixtyfold acceleration. The question will arise how far the principle of the cyclotron may be applied, and whether the energy of ions thus obtained has an upper limit. Simple considerations show that such an upper limit does actually exist.

As was shown by Lawrence, the cyclotron has focusing properties, i. e. the divergent ion beam emerging from the source is again concentrated after having passed through the cyclotron. This focusing proceeds differently in various directions. The focusing of ions, which diverge in the principal plane of the apparatus, proceeds owing to the well known ability of the magnetic field to concentrate ions after they have passed $\frac{1}{2}$, 1, $\frac{3}{2}$ etc. of the circle, while the focusing of ions, diverging perpendicularly to the principal plane, proceeds in two ways.

In the inner regions the main rôle in the focusing is played by the fields between the edges of the dees which are cylindrical electric lenses. In the outer regions the focusing does mainly depend on the non-homogeneity of the magnetic field. Owing to the decrease of the magnetic field from the centre towards the edges, there appear radial components of the field. Near the principal plane of the apparatus, these components increase linearly with the distance from that plane and have different directions at either side of the latter. The ions are deflected by the radial components of the field either in the direction towards the principal plane (if the field decreases from the centre towards the edges), or away from the principal plane, which is the case, if the field increases from the centre towards the edges, this increase resulting in a sharp decrease of the current supplied by the cyclotron.

Equation (1) is approximate and should be applied to ions of low velocities only, while in the case of high velocity ions it has to be replaced by the following equation:

$$T = \frac{2\pi m_0 c}{eH\sqrt{1-\beta^2}}. \qquad (2)$$

Both causes, i. e. the decrease of the magnetic field towards the edge of the apparatus and the increase of the ion mass with velocity, result in an increased period of its revolution and consequently destroy resonance. This destroying of resonance may be easily calculated when the increasse of energy with each separate acceleration is not great. Owing to this fact, the difference equation may be replaced by a differential equation, the error involved being insignificant.

It is evident that in practice this approximation is admissible since the number of accelerations is large. Then if the acceleration voltage is sinusoidal

$$V = V_0 \cos \vartheta, \tag{3}$$

where ϑ is the phase of the accelerating voltage, this phase and also the accelerating voltage vary on the various turns of the spiral described by the ions. It is also evident that the phase change cannot exceed π, the current in this case being zero. If the magnetic field is homogeneous and if in its centre it is so much stronger than the resonance field that the phase of the accelerating voltage at the emergency of ions from the apparatus is equal to the phase of the accelerating voltage at the beginning of the movement, i. e. $\frac{\pi}{2}$ (this is the optimum condition), then the number of revolutions and, consequently, the maximum ion energy has an upper limit. The maximum energy is equal to

$$w = 4\, m_0 c^2 \left\{ \frac{eV_0}{\pi m_0 c} + \sqrt{\frac{eV_0}{\pi m_0 c^2} + \left(\frac{eV}{\pi m_0 c^2} \right)^2} \right\}. \tag{4}$$

If we assume $V_0 = 100$ kV, then the maximum energy of the ions obtained with the cyclotron is 21.9 MeV for protons, 31.0 MeV for deuterons and 62.0 MeV for α-particles. If the magnetic field decreases from the centre to the edges the maxima will respectively decrease.

By means of a cyclotron, the magnet of which has the following characteristics: H_0 (magnetic field in the centre) = 13 000 Gauss, $\frac{\Delta H}{H_0}$ (decrease of the magnetic field from the centre to the edges) = 1%, the maximum diameter of the ion path $2R = 100$ cm, protons may be obtained of an energy equal to 13.7 MeV, and the current will flow during 38% of the half period, the magnetic focusing being still sufficient. It may be pointed out for comparison that in the Lawrence'cyclotron the ion current was flowing during 22% of the half period, yet with a somewhat better magnetic focusing.

It would thus seem that no limitation of the cyclotron power due to change in the ion mass with velocity needs to be apprehended in the near future.

N o t e. The present work was almost completed when there appeared a short notice by Bethe and Rose [3] who had studied the same problem after a similar method, but arrived at considerably different results. According to their calculations the energy limit of ions lies considerably lower (about half of our value). This is due to the fact that Bethe and Rose assume the maximum phase shift to be $\frac{\pi}{6}$, which value is evidently too low. This is also connected with another error they have made, namely, they considered the accelerating voltage to be constantly equal to V_0. Both these causes together must reduce the energy limit $\sqrt{\frac{12}{\pi}}$ times, i. e. to about one half.

Physico-Technical Institute.
Leningrad.

Received
15. III. 1938.

REFERENCES

[1] E. O. Lawrence and N. F. Livingston, Phys. Rev., **40**, 19 (1932).
[2] E. O. Lawrence and Donald Cooksey, Phys. Rev., **50**, 1131 (1934).
[3] Bethe and Rose, Phys. Rev., **52**, 12 (1937).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

PHYSICS

NUCLEAR IMPULSE IN PAIR CREATION

By L. V. GROŠEV and I. M. FRANK

(Communicated by S. I. Wawilow, Member of the Academy, 16. III. 1938)

In our previous articles ([1],[2]) angular distribution and probability of pair production in krypton by γ-rays of ThC″ were treated. In the present paper is discussed the problem of the impulse transmitted during this process to the nucleus.

1. In the case of pair production the sum of electron and positron impulses is always smaller than the photon impulse. For the electron and positron impulses we have $p_- = \frac{E_-}{c}\beta_1$ and $p_+ = \frac{E_+}{c}\beta_2$, where E_- and E_+ are the full energies of the particles, while β_1 and β_2 are their velocities, expressed in fractions of light velocity. The photon impulse $P_\nu = \frac{h\nu}{c}$. Since in the act of pair creation practically no energy is transmitted to the nucleus,

$$h\nu = E_- + E_+. \qquad (1)$$

In so far as β_1 and β_2 are smaller than 1, hence actually

$$\frac{E_-}{c}\beta_1 + \frac{E_+}{c}\beta_2 < \frac{h\nu}{c}.$$

Thus, during pair production a certain impulse P is always transmitted to the nucleus. This impulse is equal to

$$\overline{P} = \overline{P}_\nu - \overline{P}_p, \qquad (2)$$

where $\overline{P}_p$ is the impulse of the pair, i. e. the sum of the impulses of the electron and positron

$$\overline{P}_p = \overline{p}_+ + \overline{p}_-. \qquad (3)$$

The impulse of the pair depends on the direction at which the pair particles are emitted and on the energy distribution among the latter. The pair will possess a maximum impulse in the case, when the electron and the positron are emitted in the same direction, the energies of both particles being equal. For pairs of the principal line ThC″($h\nu = 5.2\ mc^2$) this maximum impulse is equal to 4.8 mc. Thus, the minimum impulse transmitted to the nucleus is in our case $P_{\min} = 5.2 - 4.8 = 0.4\ mc$ (the directions of the impulses P_p and P_ν coincide), and the maximum $P_{\max} = 5.2 + 4.8 = 10\ mc$ (P_p and P_ν are directed in opposite senses). In these limiting cases the impulse transmitted to the nucleus coincides as to direction with the photon impulse. In intermediate cases it forms with the latter an acute angle (not above 58°).

2. In our case when computing the impulse P a difficulty arises, connected with the insufficient measurement accuracy of electron and positron energies in krypton. However, a system of coordinates may be used, in which both components of the impulse P may be computed from angular measurement only, the energy of the photons producing the pairs being known. Let us choose the following coordinate system. The origin of the coordinates will be placed at the pair vertex. The plane the directions of the electron and positron emitted lie in, will be taken for the plane YZ. Let us direct axis Z along the bisector of angle φ formed by the electron and the positron directions and take as positive sense of the axis the direction inside this angle. Axis Y will then be the bisector of the complement of angle φ. Let us consider as positive the direction Y from the electron towards the positron. Axis X is perpendicular to the plane of the pair, and forms with axes Y and Z the right-hand system.

The component nucleus impulses (P_x, P_y, P_z) will be obtained from (2) as the difference of the respective components of photon impulses $(P_{\nu x}, P_{\nu y}, P_{\nu z})$ and the impulse of the pair (P_{px}, P_{py}, P_{pz}). In this case P_{px} is equal to 0, since the impulse of the pair lies in the plane YZ, $P_{pz} = (p_+ + p_-)\cos\frac{\varphi}{2}$ and $P_{py} = (p_+ - p_-)\sin\frac{\varphi}{2}$, where p_+ and p_- are the absolute values of the electron and positron impulses. Thus we get:

$$\left.\begin{aligned} P_x &= P_{\nu x} \\ P_z &= P_{\nu z} - (p_+ + p_-)\cos\tfrac{\varphi}{2} \\ P_y &= P_{\nu y} - (p_+ - p_-)\sin\tfrac{\varphi}{2} \end{aligned}\right\} \qquad (4)$$

Let us consider each of these components separately.

The component $P_x = P_{\nu x} = P_\nu \sin\alpha$, where α is the angle between the photon direction and the plane of the pair. Therefore to determine P_x it is sufficient to know the impulse of the photon P_ν and the angle α. When computing, we assumed that the pairs obtained by us had been produced by photons corresponding to the principal line of emission ThC″, i. e., $P_\nu = 5.2\ mc$. Out of 80 pairs obtained, angle α was computed for all the pairs except three. The energy of these three pairs was found to be practically concentrated in the positron, why neither the direction of the electron emitted, nor, consequently, the plane of the pair could be determined.

The component P_z depends, besides the angles, on the sum $(p_+ + p_-)$. To find this sum there is mostly no occasion to know p_- and p_+ separately. In Fig. 1 the arithmetical sum $(p_+ + p_-)$ is plotted against the full energy

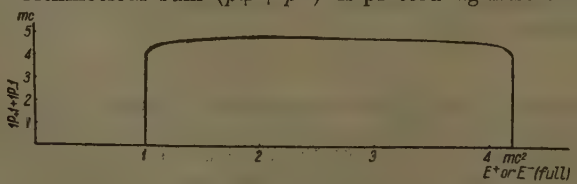


Fig. 1.

of one of the particles. The graph is built assuming that the sum of both particles $E_- + E_+ = 5.2\ mc^2$. It may be seen from this curve that value $(p_+ + p_-)$ may practically be considered as constant, provided the energy of one of the particles is not greater than 100 ekV. Only the three pairs mentioned above fail to fulfil this condition. When computing P_z for the remaining 77 pairs, $(p_+ + p_-)$ is assumed equal to $4.7\ mc$.

Thus, when determining the components P_x and P_z, the possibility of an error in the measurement of particle energy is practically eliminated.

To compute the component P_y it is necessary to know, apart from angles, also the value $(p_+ - p_-)$, which essentially depends on the energy distribution between the positron and the electron. The determination of P_y can, therefore, be made with an appreciably smaller accuracy than that of P_x and P_z. This component was calculated for 29 pairs, in which the sum of electron and positron energies measured falls within the limits 1400—1800 ekV, i. e. the energy balance is fulfilled with an accuracy to 200 ekV. Except these characters, these 29 pairs do not differ from the remaining ones by anything else. The mean value of all the angles, as well as of the components P_x and P_z, proved to coincide with the mean values computed for the rest of pairs, within the limits of error.

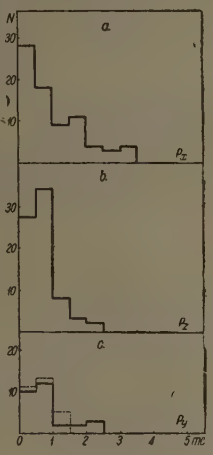


Fig. 2.

For these 29 pairs the full impulse P, transmitted to the nucleus, has also been calculated, as well as the angle formed by the photon and the impulse of the pair. The results are given below.

3. The distribution obtained for the numeric value of the component P_x, perpendicular to the plane of the pair, is presented in Fig. 2, *a*. The number of pairs with positive and negative P_x is about equal. Hence it is equally probable that P_x would form with an positron and an electron a right or a left-hand system.

As said above, P_x is proportional to $\sin\alpha$, where α is the angle formed by the photon direction and the plane of the pair. This angular distribution is plotted in the table.

Angular range. . . .	0—10	10—20	20—30	30—40	40—50	50—60	Total
Number of pairs . .	41	21	9	5	1	0	77

From the table it may be seen, that in most cases angle α has a small value, i. e. that the plane of the pair does not essentially deviate from the photon direction. The average value of $\bar{\alpha} = 12°$.

The distribution for the value P_z is given in Fig. 2,*b*. As a rule, P_z has a positive sign, i. e. this impulse component is mainly directed forward along the bisector of the angle between the electron and the positron. Hence it follows that the angle between the photon direction and the bisector of the angle φ is small. The average value of this angle $\bar{\omega} = 19°$. The impulse of the pair is usually forming with the bisector of the angle a rather small angle (in case $E_- = E_+$, it is equal to 0). It may therefore be expected that angle $\bar{\varepsilon}$, formed by the photon direction and the impulse of the pair, does not essentially differ from $\bar{\omega}$.

Among the whole of the material obtained three cases do conspicuously stand out. For these P_z possesses a value above 4 *mc*, moreover, with a negative sign (not plotted in Fig. 2,*b*). These pairs are remarkable in that the direction of the positron emission forms with the photon an angle larger than 120°. As had been previously stated, these three pairs are probably

no pairs, but reflections of Compton electrons. These three cases have been omitted from all the calculations of mean values.

The distribution of the value P_y for 29 pairs is plotted in Fig. 2,*c*. The component P_y, as well as the component P_z, assumes with equal probability positive or negative signs. The dotted line in Fig. 2,*c* gives the distribution of the value P_z for the same 29 pairs.

As seen from Fig. 2, the type of distribution is equal for P_y and P_z, and seems to somewhat differ from the distribution for P_x. The average values of the components $\overline{P}_x, \overline{P}_y$ and $\overline{P}_z$ are 1.0 *mc*, 0.8 *mc* and 0.7 *mc* respectively.

For the 29 pairs the three components of which are known, the full impulse P, transmitted to the nucleus in the act of pair production, has been computed. The results are plotted in Fig. 3. The average value of the full impulse is equal to 1.7 *mc*.

For the value of the impulse, transmitted to the nucleus, the distribution can be calculated theoretically ([3], [4]). Such calculations have been done only for energies considerably exceeding mc^2. For these energies a high probability of transmission to the nucleus of an impulse, considerably smaller than *mc*, was obtained. In our case it is impossible, since the minimum impulse, transmitted to the nucleus, is, as already stated, equal to 0.4 *mc*. It seems, however, that for the energy 5.2 mc^2 too the transmission of an impulse, not essentially different from the minimum, should be expected.

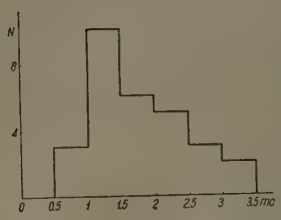


Fig. 3.

Owing to the fact that impulse P is not large, angle ε between the photon impulse and that of the pair cannot be large either. For the 29 pairs it was determined in, in 24 cases it does not exceed 25°. The average value of $\overline{\varepsilon} = 17°$, which is in good agreement with the evaluation of $\overline{\varepsilon}$, made above when analyzing the data as to the component P_z.

As already stated, when analyzing the impulses, three pairs have been omitted, in which the positron was practically carrying the full energy. For these pairs, the angle formed by the direction of the positron emission and the photon direction is equal to 5°, 10° and 14° respectively. Since in thos pairs the direction of positron motion does practically coincide with the im pulse of the pair, these angles do but slightly differ from ε, angle ε being consequently small in these pairs too.

P. N. Lebedev Physical Institute.
Academy of Sciences of the USSR.
Moscow.

Received
16. III. 1938.

REFERENCES

[1] L. V. Grošev a. I. M. Frank, C. R. Acad. Sci. URSS, XVIII, 417 (1938). [2] L. V. Grošev a. I. M. Frank, C. R. Acad. Sci. URSS, XIX, № 1 (1938). [3] H. Bethe and W. Heitler, Proc. Roy. Soc., A, **146**, 83 (1934). [4] H. Bethe, Proc. Cambr. Phil. Soc., **30**, 524 (1934).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

PHYSICS

INFLUENCE OF NOBLE GASES ON THE INTENSITY OF LINES OF HYDROGEN AND DEUTERIUM BALMER SERIES

By V. ČERNIAEV

(Communicated by S. I. Wawilow, Member of the Academy, 12. III. 1938)

It is known that the lines of Balmer series can be followed up to high members, if the discharge takes place in moist hydrogen (1), or in noble gases (He, Ne, Ar), when merely traces of hydrogen are present (2). The processes which take place here in the discharge tube are not yet sufficiently known. It is therefore of interest to compare the emission of light and of heavy (deuterium) isotopes of hydrogen under different conditions. This can furnish some additional knowledge about the behaviour of the isotopes themselves, as well as a closer approach to the correct interpretation of elementary processes in the discharge. In the present work such an attempt is made.

In order to obtain the same discharge conditions for both isotopes, the spectrum of their mixtures was investigated. A drop of 61.6 per cent heavy water* was placed inside a vessel, out of which the water vapour could be admitted by installments to a discharge tube. The discharge was produced by means of a transformer, the difference of potential between the electrodes being 1700—1800 V. A liquid air trap was placed between the pump and the discharge tube in order to avoid contamination of the discharge by mercury vapour. For the same reason the pressure in the discharge tube was not measured, since the mercury vapour from the McLeod manometer might have entered the discharge.

The influence of pressure upon the intensity of hydrogen lines was already studied many times (3). The spectra were taken across the tube in order to minimize the selfreversal of the lines. As spectral apparatus, a spectrograph with a plane grating was used. The spectra were taken through a stepped filter, and on the same plates the marks of intensity from a calibrated tungsten lamp were superimposed.

Photographs were first taken of the discharge spectra in water vapour without admixture of any foreign gas. Then the hydrogen was thoroughly pumped out and some noble gas (He, Ne, Ar) was admitted to the discharge tube. When the discharge began, there appeared a bright spectrum of the noble gas, but gradually, as the tube grew hot, the lines of hydrogen, which had been liberated from the walls and the electrodes, became apparent. After 10—20 minutes of run, when the emission of hydrogen had become very bright and that of the foreign gas rather weak, patterns were taken.

The measurements of the ratio of intensities of the deuterium lines to those of hydrogen led to the following results.

* I am greatly indebted to Prof. A. I. Brodsky for the supply of heavy water.

Table 1

Discharge in Water Vapour

Plate	3 *a*, *b**		4 *a*, *b*		5 *a*, *b*		6 *b*	7 *b*	8 *a*, *b*
Current, mA	160	235	160	250	160	250	250	250	250
$\frac{D_\alpha}{H_\alpha}$	1.17	1.15	1.23	1.22	1.25	1?	—	—	1.38
$\frac{D_\beta}{H_\beta}$	1.14	1.16	1.24	1.20	1.33	1.26	1.62	1.36	1.37
$\frac{D_\gamma}{H_\gamma}$	1.16	1.15	1.26	1.20	1.21	1.32	1.62	1.33	—
$\frac{D_\delta}{H_\delta}$	—	—	—	—	—	—	—	1.37	—

Table 2

Discharge in He with Traces of Hydrogen

Plate	3 *a*, *b*		4 *a*, *b*		5 *a*, *b*		6 *b*	7 *b*	8 *a*, *b*
Current, mA	155	240	160	250	160	250	250	250	250
$\frac{D_\alpha}{H_\alpha}$	1.59	1.38	1.48	1.46	1.58	1.50	—	—	1.33
$\frac{D_\beta}{H_\beta}$	1.67	1.40	1.54	1.53	1.70	1.69	1.78	1.41	1.55
$\frac{D_\gamma}{H_\gamma}$	1.80	1.47	1.68	1.67	1.91	1.88	1.91	1.64	1.81
$\frac{D_\delta}{H_\delta}$	—	—	—	—	—	—	—	1.91	—

It is seen from the tables that within the limits of error the intensity ratio of the lines $\frac{D}{H}$ for a given exposure is constant along the series, when the discharge takes place in water vapour (Table 1), whereas when it takes place in He (Table 2) this ratio increases towards the high members of the series. The decrease of the intensity ratio of the line of hydrogen to that of deuterium in the pair H_γ D_γ, as compared with the pair H_β D_β, was also noticed by Foster and Snell (4), when investigating the Stark effect of the lines of a hydrogen-deuterium mixture in the presence of helium. Table 2 also shows a general increase in the intensity of D lines, as compared with that of H lines, when the discharge in He takes place. In Ne discharge (Table 3), the ratio

* Here, as well as in what follows, the plates marked *a* are taken in the second order of the grating (H_α, D_α) and those marked *b* in the first order (H_β, D_β,... H_δ, D_∂).

Table 3

Discharge in Ne with Traces of Hydrogen

Plate	3 *a*, *b*		4 *a*, *b*		5 *a*, *b*		6 *b*	7 *b*	8 *a*, *b*
Current, mA	160	250	160	217	160	260	260	260	260
$\frac{D_\alpha}{H_\alpha}$	1.45	1.14	1.23	1.15	1.42	1.53	—	—	1.45
$\frac{D_\beta}{H_\beta}$	1.28	1.11	1.21	0.95	1.41	1.41	1.58	1.51	1.46
$\frac{D_\gamma}{H_\gamma}$	1.20	1.15	1.15	0.93	—	—	1.54	1.54	—
$\frac{D_\delta}{H_\delta}$	—	—	—	—	—	—	—	1.58	—

Table 4

Discharge in Ar with Traces of Hydrogen

Plate	3 *a*, *b*		4 *a*, *b*		5 *a*, *b*		6 *b*	7 *b*	8 *a*, *b*
Current, mA	160	260	160	260	160	260	260	260	260
$\frac{D_\alpha}{H_\alpha}$	1.35	1.26	1.39	1.22	1.22	1?	—	—	1.39
$\frac{D_\beta}{H_\beta}$	1.32	1.23	1.32	1.26	1.26	1.22	1.62	1.41	1.43
$\frac{D_\gamma}{H_\gamma}$	1.26	1.12	—	1.20	1.26	1.16	1.61	1.42	—

$\frac{D}{H}$ is probably decreased from α to β though this may possibly be due to errors of measurement. In Ar (Table 4) this ratio can be regarded as constant along the series.

When the intensity of the current increased, there was observed in some cases a relative decrease of D lines intensity compared to H lines (on the same plate). We have no occasion to put down this phenomenon to the intensity of the current. It may be due to the change of discharge conditions with time, since one was always taking first a pattern with a current of less intensity and afterwards one with a higher intensity of the current, the installment of gas being the same in both cases.

The relative line intensities of each isotope along the series suffered some fluctuations, owing to the influence of pressure ([3]) which was estimated solely from the aspect of the discharge, and was on an average about 1 mm, and also on account of the low accuracy of heterochrome photometry. On being averaged for pressures and errors of measurement, the observations give intensities shown in the following table.

Table 5

Content	H_2O		He		Ne		Ar		
Current, mA	165	255	160	260	162	217	265	165	265
$\frac{H_\alpha}{H_\beta}$	8.46	8.08	10.5	11.3	8.99	11.1	13.6	9.61	12.16
$\frac{D_\alpha}{D_\beta}$	8.17	7.57	9.90	10.3	9.09	13.4	14.2	9.69	11.0
$\frac{H_\beta}{H_\gamma}$	4.10	5.67	4.59	4.74	4.86	4.96	5.27	6.46	6.66
$\frac{D_\beta}{D_\gamma}$	4.30	5.57	4.14	4.26	5.11	5.09	5.29	6.47	6.92

It should be noted that notwithstanding the general increase of the intensity ratios of Table 5 with the intensity of the current, the case of $\frac{H_\alpha}{H_\beta}$ and $\frac{D_\alpha}{D_\beta}$ in the water vapour discharge is an exception, which is probably due to the selfreversal of the line $H_\alpha (D_\alpha)$. The discharge conditions, with which Jackson [3] worked, are more or less similar to those of the present investigation, and one can admit the relative intensities of both works to be in good agreement, because some undetectable differences in the discharge conditions might have noticeably influenced the intensities.

The gradual relative enhancement of D lines in He towards the high members is possibly going still further than the quantitative measurements given above. The patterns which had been made with a concave grating, without any glass optics, showed that for the high members of the series (patterns were obtained up to the 11th member) the relative enhancement of D lines, as compared with H lines, was much more marked than for the low members.

The recombination spectrum of D^+ or H^+ with an electron must have relatively more intense lines originating on high levels than has the spectrum of electronic excitement. It seems to me probable therefore that owing to the collisions of the second kind of D_2 molecules with excited He atoms atomic D^+ ions are generated, and that they are generated in a greater quantity than H^+ ions, produced by similar processes. There must be present in the discharge tube molecules H_2, HD and D_2. It seems to be evident that the probability of the processes $He^* + HD \rightarrow He + H^+ + D$ and $He^* + HD \rightarrow He + H + D^+$ is about the same. There remains the difference of the probabilities of the reactions $He^* + H_2 \rightarrow He + H + H^+$ and $He^* + D_2 \rightarrow He + D + D^+$. If one photograph is taken in the beginning of the discharge and another after half an hour of run, it is seen that on the second pattern the D lines become somewhat weaker. This points to the possibility of a stronger «clean-up effect» for the deuterium (the adsorption of free ions and atoms by the walls). Further on there may possibly occur some equilibrium between the concentrations of D and H in the gas phase and in the adsorbed layer, and during a long run of the tube the intensities of H and D lines are gradually weakened at the same rate, and the intensity of He lines is increased. This latter phenomenon also takes place in Ne and Ar discharges.

The first metastable potential of He ($V_{He} = 19.77$ V) falls within the continuum region of the molecular ion H_2^+, i. e. beyond the limit of convergence of the vibration levels of the ground state $1s^2 \sum_g$ of the H_2^+ ion, which is situated about 18 V higher than the ground state of the neutral H_2 molecule. The same limit of D_2^+ being calculated lies about 0.07—0.08 V higher than that of H_2^+. Although at a distance of the order of 1.7 V from the limit, the continuum of D_2^+ (or H_2^+) can hardly be very intense, the $He^* + D_2 \rightarrow He + D + D^+$ process is surely probable because of the liberation of the free electron which can take up the excess of energy ([5]). But the slight difference between the distances from the corresponding limits for D_2^+ and H_2^+ cannot result in a preferential ionization with dissociation for D_2 ([6]).

The molecule H_2 due to the rapprochement of two H atoms, each one occupying the second quantum level, must according to calculations have a potential curve exhibiting a minimum with a depth of 0.5—1 V at distances of 2—2.5 Å. As the asymptotic value of its energy is equal to 20.3 V, this minimum lies very near to the value of V_{He}. If now the corresponding minimum for D_2 is nearer to V_{He} than the minimum for H_2, and as during the act of collision the distance between nuclei can change ([7]), then a D_2 molecule having both of its electrons excited may result from the collision. As this molecule has a great distance between its nuclei, such small vibrational energy as the molecule might obtain could result in its transition to the unstable potential curve of the ion $D_2^+ (2p^2 \sum_u)$ (autoionization), thus bringing about its dissociation into $D + D^+$. A simultaneous double ionization of the molecule H_2 by electron impact has at any rate been observed ([8]).

As pointed out by Rice ([9]), the process of energy transfer by collision of two systems A* and B (A*—an excited one), which leads to the products A and B*, must be regarded as a process of energy transition in the «quasi-molecule» $A^* + B$ resulting in a «quasi-molecule» $A + B^*$. If the potential curves of both quasi-molecules intersect each other, the process is possible. If the two systems draw together, the potential curve of each separate system is subjected to perturbation (thus a change of nuclear distance of D_2 or H_2 may also occur). The nearer the values of energies of the colliding systems in infinity (resonance), the more probable is the energy transfer. This transfer is also rendered possible by a simple drawing together of the potential curves of quasi-molecules $A^* + B$ and $A + B^*$ ([10]).

The $He^* + D_2 \rightarrow He + D^+ + D + el$ process can, on the other hand, offer a greater probability than the corresponding process with H_2, owing to the fact that the statistical weight of the collision is proportional to $m^{\frac{3}{2}}$, where m is the effective mass of the colliding particles. But the matrix element of the energy transfer by collision also depends on m, and in the case of single intersecting levels this results in decreasing the probability with the increase of m ([10]). In our case, however, owing to a great number of possible intersections of levels, this decrease cannot be regarded as a necessary one. Unfortunately we do not have as yet the required theoretical calculations.

If the decrease of $\frac{D_\beta}{H_\beta}$ as compared with $\frac{D_\alpha}{H_\alpha}$ in the Ne discharge (Table 3) is a fact, it can be explained by the reaction which, according to Beutler and Eisenschimmel ([7]), takes place in the discharge of Ne with traces of H_2 and which results in the relative enhancement of the H_α line:

$$(2^3P_2)Ne + H_2 = (1^1S_0)Ne + H + (3^2P)H + 0.13V.$$

Here, the metastable Ne atom (16.6 V) produces in the same act the dissociation of the H_2 molecules (energy needed 4.44 V) and the excitation of one of the atoms to the three quantum state (12.03 V). But such a process is more

probable for the collision with D_2 because the energy of dissociation of D_2 is about 0.07 V higher than that of H_2, and the excitation energy of D atom is also 0.003 V higher than that of H. Therefore in such collisions with D_2 there remains an excess of energy of only 0.06—0.05 V, i. e. the resonance is sharper, and thus the process is more probable.

It is pleasure to me to express profound gratitude to Prof. S. E. Frisch, under whose guidance this work was done, for his valuable advice and suggestions. I also wish to thank Prof. A. N. Filippof for placing at my disposal the plane grating of his laboratory, and P. P. Pavinsky and M. G. Veselov for helpful discussion.

Laboratory of Molecular and Atomic Spectroscopy.
State Optical Institute.
Leningrad.

Received
17. III. 1938.

REFERENCES

[1] R. W. Wood, Proc. Roy. Soc. Lond. (A), **97**, 455 (1920). [2] T. R. Merton a. J. W. Nicholson, Phil. Trans., **217**, 237 (1918); Proc. Roy. Soc. Lond. (A), **96**, 112 (1920); T. Takamine a. T. Suga, Sc. Pap. Inst. Phys. Chem. Res. Tokyo, **14**, № 265, 117 (1930); E. Lau u. O. Reichenheim, ZS. f. Phys., **73**, 31, (1932). [3] L. S. Ornstein u. H. Lindemann, ZS. f. Phys., **63**, 8 (1930); W. W. Jackson, Phil. Mag., **22** (VII), 633 (1936). [4] J. S. Foster a. H. Snell, Proc. Roy. Soc. Lond. (A), **162**, 349 (1937). [5] R. Frerichs, Ann. Phys., **85**, 362 (1928); J. Takahashi, Ann. Phys., **3**, 27, 49 (1929). [6] F. M. Penning, Physica, **12**, 65 (1932). [7] H. Beutler u. W. Eisenschimmel, ZS. f. Elektroch., **37**, 582 (1931). [8] W. Bleakney, Phys. Rev., **35**, 1180 (1930); W. W. Lozier, Phys. Rev., **36**, 1285 (1930). [9] O. K. Rice, Phys. Rev., **37**, 1187, 1551 (1931). [10] L. Landau, Phys. ZS. Sow., **1**, 88; **2**, 46 (1932).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

PHYSICS

GYROMAGNETIC EFFECT IN SUPERCONDUCTORS

By I. K. KIKOIN and S. V. GOOBAR

(Communicated by A. F. Joffe, Member of the Academy, 5. III. 1938)

Since the works of Meissner, Ochsenfeld (1) and others have appeared in print, it has been known that superconductors differ from normal metals by their magnetic induction being zero. This signifies that a superconductor placed in a magnetic field possesses a diamagnetic susceptibility, $\varkappa = -\frac{1}{4\pi}$. A superconductor is, thus, at the same time a superdiamagnetic substance in the sense that it is endowed with the greatest conceivable diamagnetic susceptibility. The availability of such very high magnetic susceptibility permits of checking experimentally the existence of the so-called gyromagnetic effect in superconductors.

By the gyromagnetic effect is understood a phenomenon due to which, in course of the alteration of the magnetic moment of a body, there arises a mechanical impetus (the Einstein- de Haas effect). The gyromagnetic effect was hitherto observed on ferromagnetic and paramagnetic bodies. It would be absurd to seek for this effect in ordinary diamagnetic bodies, because of the smallness of the magnetic susceptibility of such bodies. Besides, this effect cannot be declared a priori to exist in diamagnetic bodies and notably in superconductors; indeed, the mechanism of magnetization of paramagnetic and ferromagnetic bodies differs essentially from the mechanism to be found in diamagnetic bodies. With paramagnetic and ferromagnetic bodies the existence of a gyromagnetic effect is caused by the fact that here the mechanical momentum of the electrons of an atom $\vec{P}$ (this impetus may be orbital or axial and it may subsist also without an external magnetic field) is necessarily attended by a corresponding magnetic moment $\vec{M}$; for orbital impetus $\vec{P} = l\frac{h}{2\pi}$ the magnetic moment is $\vec{M} = \frac{l}{2mc}\vec{P}$, while for axial impetus (spin) $\vec{P}_1 = S\frac{h}{2\pi}$, it is $\vec{M}_1 = \frac{l}{mc}$ (l and S being respectively quantum numbers).

The availability of an interaction between the electrons and the ions of the lattice leads to every change in the magnetic moment of the body as a whole involving a corresponding change in the mechanical impetus of that body, i. e. we have torque. By measuring torque, it becomes possible to determine the ratio $\frac{P}{M}$. This ratio equals $\frac{2mc}{l}$ for the orbital impetus and

$\frac{mc}{l}$ for the axial impetus (spin), or for the general case we have $\frac{P}{M} = \frac{1}{g} \cdot \frac{2mc}{l}$ ($g = 1$ for the orbital impetus and $g = 2$ for the spin). Coefficient g coincides with the value of Lande's factor.

With superconductors, as with all diamagnetic bodies in general, the magnetic moment appears only in the outer magnetic field, without which the superconductor will have no moment whatever. Moreover, the statement has been made that the infinitely great conductivity of superconductors is caused by the lack of any interaction between electrons and lattice ions, and if this is so, it becomes clear that under no conditions whatever can the gyromagnetic effect be at all observed here.

In view of the great interest of this problem, we carried out an experimental investigation of the gyromagnetic effect on superconductors. In deciding upon the most suitable method of procedure, we at last fixed our choice on the so-called resonance method, which was first proposed by Einstein and later developed dy Scherer and Coeterier (2). The method consists in suspending the specimen by a thin thread in a periodically alternating magnetic field located parallel to the gyration axis of the specimen (the specimen is usually of cylindrical form), the period of the field being so selected as to be equal to the period of the natural oscillations of the specimen. Owing to the periodical overmagnetization of the specimen, periodical torque arises, which acts upon the specimen, swinging it to the amplitude of resonance. The latter is determined by the formula:

$$A = \frac{2M\lambda}{\pi g K \delta}, \qquad (1)$$

where M is the magnetic moment of the specimen, $\lambda = \frac{l}{2mc}$, K—the moment of inertia of the specimen relatively to the axis of gyration, δ—the logarithmic decrement of damping and g — the Lande's factor. Measuring this resonance amplitude and knowing the values of M, K and δ, it is possible to determine the Landes' factor, g.

The measurement of the gyromagnetic effect is, as well known, greatly complicated by numerous side effects, which it is usually attended with. These side effects are in the main due to the impossibility of precise centering of the specimen in both the mechanical and the magnetic sense; accordingly, particular attention was paid to the elimination of these effects. As suitable material for the specimen, lead was selected, to which we imparted the spherical shape, that shape being known as the most advantageous for eliminating the side effects mentioned. With ideal spherical form most of the side effects are, indeed, entirely obviated. However, inevitable small deviations from the absolutely true spherical form permit of disregarding these side effects only in the first approximation. Besides this, we made use of a special autoresonant thyratron set intended for switching over the current of a solenoid. In this set the oscillating specimen itself is capable of switching over the current in the solenoid in a manner, similar to that suggested by Scherer and Coeterier (2).

The advantage of our set-up lies in the fact that it eliminates all secondary torque to be found within the circle with the gyromagnetic gyratory moment (and most side effects satisfy this condition). The combination of our system of suspension with the autoresonant set, in fact, almost fully safeguards the obtained results from any distortion through numerous side effects. It stands to reason that the «usual» precautionary measures were also taken in order to minimize the aforesaid unwanted effects.

In order to make a check on the apparatus a rough measurement of the Lande's factor for an iron cylinder was made. The obtained value of $g = 1.95$ is

sufficiently close to the value $g=2$ obtained by a number of authors in result of precise investigations. Experiments performed with several lead specimens at the boiling point of liquid helium (4.2° K), in fields considerably below the critical one, showed that the Einstein-de Haas effect does actually exist; the numerical value of g, as measured by us, was found equal to $1\pm3\%$. The sign of the effect, i. e. the sign of the ratio of the magnetic moment to the mechanical impetus, is negative (—), as was to be expected for electrons. It should be noted that the interpretation of the results obtained is as yet difficult, for want of a modern molecular theory of superconduction. It seems, indeed, impossible to ascribe the existence of a gyromagnetic effect in superconductors to the influence of electron inertia in eddy currents (Tolman's effect), which might arise in superconductors located in an alternating magnetic field.

In a single-bond superconducting body, such as our specimen, eddy currents are incapable of arising, since, otherwise, magnetic induction within the superconductor would fail to equal zero.

A detailed description of our experiments and a discussion of the results obtained will be published elsewhere.

The work was conducted in the cryogen laboratory of the Ural Physico-Technical Institute.

The Ural Physico-Technical Institute.
Sverdlovsk.

Received
19. III. 1938.

REFERENCES

[1] Meissner and Ochsenfeld, Naturwiss., **21**, 787 (1933). [2] F. Coeterier and P. Scherer, Helv. Phys. Acta, **5**, 217 (1932).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GEOCHEMISTRY

ON SOME ISOMORPHIC SUBSTITUTIONS IN APATITE

By I. D. BORNEMAN-STARINKEVITCH

(Communicated by A. E. Fersman, Member of the Academy, 20. III. 1938)

Several works have appeared lately on new isomorphic substitutions in apatite ([1–5]). The usual chemical formula for fluoapatite, $3Ca_3(PO_4)_2 \cdot CaF_2 = Ca_{10}P_6O_{24}F_2 = 2Ca_5P_3O_{12}F$, is expanded to the general formula, $A_5B_3X_{13}$, in which A may be replaced with Ca, Sr, Ce, Mn, Na, K; $B \rightarrow$ P, As, V, Si, S; $X \rightarrow$ F, (OH), Cl, O. Still another substitution is suggested by Grumer and McCannel: calcium with carbon, and phosphorus with carbon.

I. I have already analyzed the possibility of substituting Ca, Ce, Na and P, Si as far as solid solutions of uniform chemical compounds with cations and anions of various valency are concerned. I was able now to trace the compounds $/Ca_3NaCe/ \cdot P_3O_{12}F$ and $/Ca_4Ce/\ P_2SiO_{12}F$ in the composition of some of the Khibin apatites. The analyses and ionic ratios in apatites from two beds are given below:

I. Takhtarvumtchor (Molybdenum mine)

M. I. Volkova's analysis

Sp. gr.*	CaO	SrO	TR	MgO	MnO	P_2O_5	F	SiO_2	H_2O	Total
3.295	50.56	3.91	1.73	0.11	0.03	40.59	2.48**	0.69	0.25	100.35
	9028	377	105	27	—	5717	1305	115	273	

II. Kukisvumtchor (fine-grained)

I. D. Borneman's analysis

Sp. gr.*	CaO	SrO	Ce_2O_3	(Y. $La)_2O_3$	Fe_2O_3	Na_2O	K_2O	P_2O_5	F	Total
3.240	53.35	2.43	0.36	0.51	0.05	0.08	0.09	41.03	3.40	101.30—1.43
	9433	235	21	31	—	26	19	5779	1889	

In the first analysis the ratio of Si and Ce ions equals 1 (115:105 = 1.1) which corresponds to the component $/Ca_4Ce/P_2SiO_{12}\ F$; in the second analysis the ratio Ce : Na = 1 (51:45 = 1.1) which corresponds to the component $/Ca_3CeNa/P_3O_{12}\ F$. The whole composition of these apatites may be expressed in the following ratio of compounds:

1. Takhtarvumtchor: 90.6% $Ca_5P_3O_{12}F$; 3.9% $Sr_5P_3O_{12}F$; 5.5% $(CeCa_4)P_2SiO_{12}F$.
2. Kukisvumtchor: 95.0% $Ca_5P_3O_{12}F$; 2.4% $Sr_5P_3O_{12}F$; 2.6% $(CeNaCa_3)P_3O_{12}F$.

* The specific gravity was determined by Z. M. Gileva.

** The figure F is lowered; it was determined after Berzelius method, which is very complicated for phosphates.

The analysis errors involved in the determination of P_2O_5 and F are as follows: in the first analysis there is 71% P_2O_5 more and 62% F less than there should be according to the composition in question (see comment to the analysis table); in the second analysis there are 0.61% P_2O_5 and 0.13% F less than there should be.

II. The possibility of substituting carbon for calcium (Ca—C), as supposed in francolite by Grumer, is doubtful in point of the possible existence of a chemical salt compound with carbon as the cation; the existence of CO_4^{-4} ions is also unlikely. Calculating the ratio of the valencies of the carbons to the valencies of the anions PO_4^{-3}, SiO_4^{-4}, CO_3^{-2}, Ce^{-1}, F^{-1}, $(OH)^{-1}$ in the following analysis of the francolite

CaO	MgO	P_2O_5	V_2O_5	CO_2	F	H_2O	H_2O	Total
54.88	0.31	37.71	0.24	3.36	4.11	0.90	0.04	101.79—1.73
9788	77	5310	26	763	2163	1266		

without taking water into account, we get $K : A = 19\ 730 : 19\ 685$ and taking the water into account 19 730 : 20 951; if the CO_4^{-4} ion is assumed to be present, the anion valence should rise and the ratio should deviate from unity.

The nonconformity between the requirements of chemical theory and the crystallo-chemical construction can be smoothed over by assuming the existence of the molecule $3CaCO_3 \cdot 2Ca(F,OH)_2 = Ca_5C_3O_9(F, OH)_4$, which is of the apatite molecule type: $A_5B_3X_{13}$ and which does not require the CO_4^{-4} ion. In the crystal lattice the configuration of the tetrahedron of oxygens around the carbon may keep, in correspondence with the oxygen tetrahedron around phosphorus, but one of the oxygens is substituted with fluorine, or with the (OH) group. The existence of the minerals: parisite $2CeCO_3F$. $CaCO_3$ and bastmasite—fluorcarbonates of the rare earths and calcium, make this supposition quite probable.

The composition of the francolite in question may be expressed as follows:

$$90.2\%\ Ca_5P_3O_{12}F;\ 4.9\%\ Ca_5C_3O_9F_4;\ 4.9\%\ Ca_5C_3O_9(OH)_4.$$

In the figures of the analysis the nonconformity with this composition is evident in the excess of H_2O and CO_2 : 0.80% CO_2 and 0.79% H_2O which probably shows the active process of the substitution P—C, i. e. that there is an aqueous solution of carbonic acid in the pores of the crystal.

III. I was successful in obtaining a wonderfully pure sample of apatite from the Karpinsky museum from the American Hastings Co, the analysis of which as a pure fluoapatite was cited by McConnell [4] and made by Dodson [5].

Sp. gr.	CaO	MnO	FeO	Fe_2O_3	Al_2O_3	P_2O_5	F	Ce	CO_2	H_2O	H_4	Total
3.197	55.16	0.12	0.14	0.63	0.24	41.30	3.67	0.09	0.50	0.01	0.28	102.14
	9850	17	—	—	—	5817	1931	25	114	11	47	

An analysis which I made showed that the apatite in this layer contains 0.83% rare earths and only 0.17% Fe_2O_3 and no Al_2O_3, in other words, iron and aluminium were taken as rare earths during the analysis. It is very easy to make such a mistake, if rare earths are not supposed present, since the total of rare earths may easily be taken for the total of $Fe_2O_3 + Al_2O_3$, owing to the similarity of the reactions in which the hydroxides are precipitated and to the similarity of the colour of the heated oxides to ferric oxide. When the oxides are dissolved and reduced in order that the iron may then be determined by titration, CeO_2 changes into Ce_2O_3 and is then titrated with permanganate.

The material for analysis is so pure, that the Dodson's insoluble substance may be assumed to be SiO_2. Assuming this apatite to be composed of compounds with formulae of the type $A_5B_3X_{13}$, we get the following composition for it: 96.1% $Ca_5P_3O_{12}F$; 2.5%$Ca_4CeP_2SiO_{12}F$ and 1.4% $Ca_5C_3O_9(OH)_4$. The nonconformity with the figures of chemical analysis is an excess of 0.15% CO_2 and a deficiency of 0.09% H_2O, i. e. the analysis wholly coincides with the supposed chemical composition.

IV. The substitution P—S—Si was found by McConnell to be possible in the minerals ellestedite (Ellested's analysis) and wilcoite (Eakle's analysis).

Analysis of Ellestedite

Sp. gr.	CaO	MgO	MnO	CO_2	P_2O_5	SO_3	SiO_2	Ce
3.068	55.18	0.47	0.01	0.61	3.06	20.69	17.31	1.64
	9841	117	—	139	430	2584	2882	462

F	H_2O	H_2O	Fe_2O_3	Al_2O_3	Total
0.57	0.53	0.10	0.22	0.13	100.52
300	590	—	—	—	

Taking the presence of vesuvianite into account, as indicated by McConnell, we get the following composition for ellestedite: 87.7% $Ca_{10}S_3Si_3O_{24}F_2$; 7.3%$Ca_{10}P_6O_{24}F_2$; 3.5% $Ca_{10}Si_6O_{18}(OH)_8$; 1.5% $Ca_{10}C_6O_{18}(OH)_8$; according to the analysis there is an excess of CO_2 of 0.19% and a deficiency of H_2O of 0.81%. Ellestedite is an apatite, in which the phosphorus atoms are displaced with an equal number of atoms of sulphur and silicon.

I analyzed some apatite from the Shishim mine (Urals), one of the members of the isomorphic series apatite—ellestedite:

CaO	Na_2O	K_2O	SO_3	SiO_2	P_2O_5	Ce	F	CO_2
56.26	0.08	0.07	3.24	5.95	32.40	0.55	1.10	—

This apatite has an ion ratio Si : S$>$1, a «silico-apatite» $Ca_5Si_3O_9(OH)_4$; synthesis will show the probability of this.

Conclusion

The chemical compounds of which apatite is composed, were given the following unitype formulae:

$$/Ca_{10}/P_6O_{24}F_2 = 6Ca_3(PO_4)_2 . 2CaF_2 = 2\,/3Ca_3(PO_4)_2CaF_2/;$$
$$Ce_2Na_2Ca_6\,/P_6O_{24}F_2 = 2CePO_4 . 2Ca_3(PO_4)_2 2NaF = 2\,/CePO_4Ca_3(PO_4)_2NaF/;$$
$$Ce_2Ca_8\,/P_4Si_2O_{24}F_2 = 2CePO_4Ca_3(PO_4)_2 . 2Ca_2SiO_4 . CaF_2;$$
$$Ca_{10}\,/P_2S_2Si_2O_{24}F_2 = 2CaSO_4Ca_3(PO_4)_2 . 2Ca_2SiO_4 . CaF_2;$$
$$Ca_{10}\,/S_3Si_3O_{24}F_2 = 3CaSO_4 . 3Ca_2SiO_4 . CaF_2;$$
$$Ca_{10}\,/C_6O_{18}\,(F, OH)_8 = 6CaCO_3 4Ca\,(F,OH)_2 = 2\,/3CaCO_3 2CaF_2/;$$
$$Ca_{10}/Si_6O_{18}\,(F,OH)_8 = 6\,CaSiO_3 . 4Ca\,(F,OH)_2 = 2\,/3CaSiO_3 . 2CaF_2/.$$

The analysis above confirms that apatite is composed of various mixtures of these compounds.

A correction was made in the analysis of flouoapatite of Hastings Co (Dodson's analysis) regarding the content of rare earths.

An analysis has been given of an intermediate member of the series apatite—ellestedite, viz., of the apatite of the Shishim mine (Urals).

Received
17. III. 1938.

REFERENCES

[1] McConnell, Amer. Min., **22**, 977 (1937). [2] McConnell, ibid., **23**, 1 (1938). [3] Grumer a. McConnell, Zs. Kr., **97**, 208 (1937). [4] И. Борнеман-Старынкевич, Сб. В. И. Вернадскому, I, 735 (1936). [5] Dodson, Univ. Toronto Studies, Geol. Surv., **35**, 51 (1933).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GEOCHEMISTRY

SPECTROSCOPICAL ANALYSIS OF THE PRODUCTS OF LEAD AND ZINC PLANTS

By S. A. BOROVICK and S. K. KALININ

(Communicated by A. E. Fersman, Member of the Academy, 8. III. 1938)

The spectrum analysis laboratory of the Lomonosov Institute has disclosed the presence of In, Ge, Ga and a number of other rare elements in many deposits of polymetallic ores. Occasionally, the concentration of these elements was even ascertained to be so considerable, that it was found feasible to extract some of them in the pure form; indeed, such ores may be considered as independent raw material for the extraction of In, Ge and Ga. But under practical conditions, polymetallic ores serve only for the recovery of lead, zinc and cadmium, while the valuable rare metals go to the dumps and become irretrievably lost through insufficient attention being paid to them. And all at the same time, the reclaiming of rare or scattered elements in the process of working polymetallic ores is one of the most burning questions of the day for the bulk of the industrial enterprises of the Union.

Usually, polymetallic ores besides lead and zinc contain varying quantities of Cd, Bi, Sb, As, Ga, In, Ge, Sn, Mo, Co, Ni and some other elements. However, the problem of the distribution of these elements in the products of smelting and other metallurgical operations has so far received but insufficient attention. In the present article we state the results of a study of the products of metallurgical operations at lead plants with particular reference to the determination of rare elements. All in all, 35 products of the Tchimkent lead plant, 7 products of the Ridder cadmium plant, 15 products of the Ridder lead plant and 15 products of the Belov zinc plant were analyzed, with a total of 1800 determinations of separate elements.

The spectra were obtained with the help of the intermediate model of the Hilger quartz spectrograph. The deciphering of the results obtained not only permitted of ascertaining the presence of this or other element in the sample in question, but also warranted conclusions with respect to the relative concentration of that element in the given material. Such conclusions were made by observing the intensity of the respective lines in the spectrum. Many of the samples were found to have a very complex chemical composition and contained up to 25 or even more different chemical elements.

We shall not produce here all the material gathered; this would have occupied too much space, while presenting interest only to a narrow circle of specialist; we intend to dwell here only upon the most interesting elements.

G e r m a n i u m is to be found in speiss. Its presence, amounting to about 0.1%, was observed in the speiss of the big water-jackets of the Tchimkent lead plant and also in the speiss of the experimental plant. Faint lines, disclosing the presence of about 0.005% Ge, are also to be seen in the spectrum of the copper-cadmium cake of the Ridder cadmium works.

I n d i u m has been found to occur in the Cottrell dust of the experimental plant where dry schlichs are treated; also in the Cottrell dust of big water-jackets and in the dry schlichs of the Tchimkent lead plant. Weak

lines, disclosing the presence of about 0.005% In, were to be seen in the spectrum of copper-cadmium cake; and somewhat fainter lines could also be seen in the spectrum of rich schlichs and the spongy cadmium of the Ridder plant.

Gallium. No appreciable concentration of gallium could be observed in the investigated products of lead plants; but a comparatively high concentration of this element has been found to exist in the copper-cadmium cake of the Ridder cadmium works.

Cobalt appears to be accumulated in the speiss and the dry schlichs of the Tchimkent lead plant.

Nickel occurs in speiss, dry schlichs and flue dust from the cupellation department, while nickel bands are also observable in the case of the matte and dross of the Tchimkent lead plant. At the Ridder plant the presence of Ni has been ascertained in copper-cadmium cake, schlichs and matte.

Molybdenum is concentrated in speiss and also in such blast-furnaces slags which can still be treated for recovery of metal values; it is observable in the schlichs of the Tchimkent lead plant and in the copper-cadmium cake of the Ridder cadmium plant; finally, it occurs in the schlichs of the Ridder lead plant and in some other products.

Vanadium is to be found in the flue dust of the cupellation department of the Tchimkent lead plant.

Cadmium is concentrated in the litharge and Cottrell dust of the Tchimkent lead plant; in baghouse and Cottrell dust of the Ridder zinc plant; in the flue and Cottrell dust of the Belov zinc plant. The presence of cadmium has also been ascertained in several other products of metallurgical operations.

Arsenic occurs in the speiss, schlich and Cottrell dust of the Tchimkent lead works; in the copper-cadmium cake of the Ridder cadmium plant; in the baghouse dust, Cottrell dust, litharge and schlichs of the Ridder lead plant; also in the Cottrell dust of the Belov zinc plant.

Antimony is concentrated in the litharge, speiss and schlichs of the Tchimkent lead plant; also in the stibiated slags, litharge and other products of the Ridder lead plant. Faint antimonial lines have been found in the spectrum of Cottrell dust of the Belov zinc plant and also in that of the copper-cadmium cake of the Ridder cadmium plant.

Bismuth is concentrated in the schlichs and the zinc dust from the cupellation department; in work-lead and other products of the Tchimkent lead works; in the copper-cadmium cake of the Ridder cadmium plant; in the schlichs, rich litharge, baghouse dust and some other products of the Ridder lead plant.

Tin has been found to be available in the speiss, schlichs and Cottrell dust of the experimental plant; in the drosses and such slag as still contains some metal values of the Tchimkent lead plant; in the copper-cadmium cake of the Ridder cadmium plant and in the baghouse dust of the Ridder lead plant.

We shall limit our list to this, having as our main purpose to show the insufficiency of the routine chemical analysis by which every metallurgical process is controlled as a matter of fact, such analysis fails to give and in many cases is incapable of giving indications on the availability and distribution of rare and scattered elements. The best course is to have spectroscopic analysis precede the chemical one; then the very execution of chemical analysis is much simplified and more exhaustive information on the composition of the test-sample can be obtained.

Received
8. III. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GEOLOGY

ON THE CARBONIFEROUS GYPSUMS AND THE RED DEVONIAN SANDSTONES OF TYAN-SHAN

By A. V. PEIVE

(Communicated by A. D. Archangelsky, Member of the Academy, 10. III. 1938)

In the last years some facts habe been established, which are of principal interest for certain general conclusions concerning the geology of Tyan-Shan.

In 1935 the present author has encountered gypsum beds, some hundred meters thick, at the northern slope of Kavaktau between the Naryna and Kokomerona rivers. Gypsums are light and greenish with bands of argillite, sandstones and limestones. No traces of rock salt have been found in this thick gypsum series; the springs here have a salty-bitter taste with discolorations and crusts of gypsum. At the same time the gypsums of Kavaktau were studied by the geologist N. M. Sinizyn. According to his own observations, the author has formed the opinion that the gypsums are overlain by Visean limestones and from their age belong to the lower part of the Lower Carboniferous and, probably, in part to the Devonian. N. M. Sinizyn, apparently with good reason, regards these gypsums as Middle Carboniferous, since he discovered *Choristites* sp. in the bands of limestone.

On the Dongruma river and also at the northern slope of Kavaktau the author has observed a horizon of gypsums of a different age, associated with the red-coloured Visean facies and located among beds with *Gigantella* ex gr. *rectestria* and *Striatifera striata*. Considerably thicker gypsum beds (150—200 m) have been found at the mouth of the Kokomerona and on the Turuk river, along the northern slope of Kokirimtau. These gypsums are also connected with the Carboniferous: directly under them *Gigantella* ex gr. *rectestria* has been found, and above the gypsums in the core of the syncline dark argillaceous limestones are lying, in which no fauna has been found; these are probably Middle Carboniferous (?). Gypsums have been observed also in the Carboniferous of the Takhtalyk ridge.

Thus, the presence of a very thick series of sandstones, argillites and gypsums with bands and packs of limestones in the Lower and Middle Carboniferous is characteristic of this region.

The above facies of the Carboniferous are located in a comparatively narrow strip along the northern slope of Kokirimtau, Kavaktau and, most likely, stretch still further to the east.

It should be necessary to emphasize that the described facies of the Carboniferous substantially differ from the thin continental-lagoon deposits of the same age, of the axial part of the Caledonian Tyan-Shan (Susamyrtau,

Dzhumgoltau and others), on the one hand, and the typical marine deposits of northern Fergana and southern Tyan-Shan on the other. The deposits described should be considered as intermediate, transitional formations between the typical «south» and «north» facies, the character of which is well known in literature.

The Devonian deposits are also of considerable interest since they enable to make out the peculiarities of this transitional area. Thick, red-coloured sandstones and conglomerates have been observed by the author and also by N. M. Sinizyn immediately to the south of Kavaktau in the Akshyryak ridge, the upper part of which passes to limestone of the Upper Devonian—Lower Carboniferous. Even though no fauna has been found in these deposits, they should be referred to the Middle and, probably, to the Lower Devonian from their stratigraphic position and from the analogy with more western regions. There are some vague indications of V. N. Ognev about his having found also thick clastic rocks in the Devonian of Kokirimtau.

In the Angren-Chatkal region these deposits have been known for a long time, but the latest investigations of A. S. Adelung, N. M. Sinizyn and others have considerably widened the informations regarding the Devonian beds.

According to A. S. Adelung's data, these deposits in places unconformably overlie the Upper Silurian. V. N. Ognev shows an unconformity between the Lower Devonian and the Upper Silurian for north Fergana.

The above facts evidence two phenomena: first of all they lead us to the conclusion, that the folding of the Caledonian Tyan-Shan stretches in time up to the Middle Devonian, and for this reason in the southern marginal zone of the northern Tyan-Shan in the anticline saddles an unconformity exists between the Devonian and the Upper Silurian.

The second conclusion is that along the southern margin of the northern Tyan-Shan which is forming and worn down at the same time, littoral sediments are deposited in the Devonian. The northern Tyan-Shan is a barrier also for the Carboniferous and this is why we observe a thick accumulation of sediments along this barrier; in places lagoons are formed, in which thick beds of gypsum are deposited.

Unstable and various fauna is typical of this zone.

The whole of this area of the western Tyan-Shan, characterized by a specific accumulation of sediments, may be considered as a marginal southern zone of the Caledonian Tyan-Shan, in which the major folding developed already in the Upper Paleozoic. The peculiarities of the structures and the character of the volcanism make it possible to isolate this zone as an independent structural unit of the Tyan-Shan.

The Geological Institute
of the Academy of Sciences of the USSR.
Moscow.

Received
11. III. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GEOLOGY

THE TERRACES OF THE DNIESTER

By L. LUNGERSHAUSEN

(Communicated by A. A. Borissiak, Member of the Academy, 17. III. 1938)

At the close of the Miocene a wide sloping plain stretched at the place of the Galician Bay of the Sarmatian Sea, whose western continuation may be easily traced in the continental facies of the Upper Sarmatian and Maeotian of Bessarabia. This peripheric plain, bordering the coast of the Neogene seas, has a complex hydrographic system, chiefly of a consequent drain centred inward, to the sea coasts with variable outlines. The conditions and peculiarities of this hydrographic system reflect completely the unquiet course of the phase of formation (uplift) of the region adjoining the Carpathians: in the vertical section of the Balta plain horizons are found, which evidence the acceleration of erosion or, on the contrary, its slowing down, or even complete cessation, i. e., traces of numerous cycles of denudation. Only at the close of the Pliocene, however, river systems first originated, which are linked by a clearly pronounced succession with the present time and Quaternary hydrography. The origin of the Dniester valley is referred to the same period.

Extensive sheets of areno-pebbly accumulations and terraces proper have been recorded in the Dniester Basin. The former are referred to the Pliocene, the latter to the Quaternary.

The Upper or the old Kuchurgan cover, preceded by plain sheet erosion, crowns the areno-argillaceous complex of the Balta plain. It encloses the huge territories of the Dniester and Bugh rivers basin, passes to Bessarabia (the Levantinian) and is analogous to a similar gravel in East and West Europe, composing a peculiar (local) Upper Pliocene facies of the Alpian zone. Abundant violet and red sandstones of the flysch are evidence of the Carpathian roots of the Kuchurgan cover; the peculiarities of the mantle rock and the type of cross-bedding as well as the worn state of the clastic material, confirm its fluvioglacial origin. Clearly pronounced lines of the drain have not been localized during this epoch. The river valleys have not been investigated. Fauna: *Mastodon* sp., *Cervus* sp., *Rhinoceros longirostris*, *Hipparion non gracile*, *Canis* sp., *Felis* sp., *Gazella* sp., *Camelopordalis* sp., *Lepus* cf. *laskarevi*, *Ochotona* sp., *Myolagus meyeri*, *Aves*, *Pisces*, *Testudo*, *Unio* ex gr. *flabellatus-flabellatiformis*, *Unio haueri*, *Unio* sp. *indet.* (very large smooth forms), *Neritina* sp., etc. Approximate marine equivalents: the Kuyalnyk (partially older strate?), the Akhchagyl (?).

Young Kuchurgan jasper chalcedony and flysch gravel covers the bottom of the so-called late Kuchurgan ravine and corresponds to the close of the Pliocene. It is separated from the old cover by a 50 m

deep erosion. At that time there were formed wide (up to 40—50 km) ravines, spacious trenches along which torrents of fluvioglacial waters were rushing southwards. The Kuchurgan gravel of both levels is covered by patches of ancient loess, weathered (during the pre-Quaternary interglacial) to bright-red loam of the *terra rossa* type. Higher up heavy («syrt») clays and loess beds are lying (only at the upper level?). The late Kuchurgan ravine presents the oldest (upper) cut, in its principal features corresponding to the set of the Quaternary Dniester.

The ancient river terraces show eight separate levels, which may be grouped to five main stages. At the base of each terrace coarse boulder-pebbly accumulations (valley fluvioglacial) are lying, referred to the closing periods of glacial phases. The beds of river sediments proper present an instructive illustration of the alteration of sediments, which is an evidence of a slowing down erosion (the development of the equilibrium profile). Most of the terraces show a complete geomorphological cycle; only some of the terraces are formed under the conditions of an incomplete, suddenly interrupted cycle (the Grigoriopol terrace).

The Kolkotov stage (Vα and Vβ). At the base—a thick boulder-pebble drift, referred to the Quaternary glaciation (Gunzian?). In the upper rubble horizons the following fauna has been found: *Paludina zsigmondyi*, *P. pseudoartesica*, *P. calverti*, *P. craiovensis*, *P. tiraspolitana-bythinica*, *P. kagarlitica*, *P.* aff. *depereti*, *Neritina quadrifasciata*, *N. punctatolineata*, *N. liturata*, *Melanopsis esperi* var. *lineata*, etc. Higher up lies the chief alluvial series of the terrace with *Paludina getica*, *P.* aff. *rhodensis*, *P.* aff. *rhodensis-acramitica*, *P.* aff. *grandis*, *P. sadleri-alta*, *P.* cf. *sadleri*, *P. calverti*, *P. craiovensis*, *P.* aff. *böckhi*, *P. parlowi* (*P. böckhi* Pavl. non Halav.), *P. tiraspolitana*, *P. conoid-angusta*, *P. tiraspolitana* var. *subcrassa*, *P. diluviana* var. *subgracilis*, *Pal. subcontecta*, *Melanopsidae*, *Neritinae*, *Unionidae*, etc. There are also *Elephas meridionalis*, *Equus stenonis*, etc. The main beds are referred to the first Quaternary interglacial (Gunzian-Mindelian?). Towards the close of the latter the formation of the upper level of the terrace (Vβ) has been completed; the lower level (Vα) has been drained only during the Tirass (Mindelian) interstage. The equivalents of the terrace are: the oldest quarter of Mauer, the Forest beds of Norfolc, the lower sands of Mosbach, the Chauda, the upper horizons of the fresh-water Pliocene of Hungary (*Szentes*, etc.).

The Tiraspol stage (IVα and IVβ). At the base a valley fluvioglacial of the second Quaternary glaciation (Mindelian?) is lying. In the upper portion of the rubble occasional *Unio* and minute *Corbicula* aff. *fluminalis* of the Baku type are encountered. In the main formation of the alluvial sands an abundant fauna is found: *Paludina diluviana-gracilis*, *P. diluviana-crassa*, *P. ripi*, *P. pseudo-sadleri-ripi*, *P. beresanica*, *P. romaloi*, *P. zickendrathi*, *P. sokolovi*, *P. isteriena*, *P.* aff. *contecta*, *P.* aff. *subcontecta*, *P. cretzestiensis*, *Unio tumidus*, *U. crassus*, *U. batavus-hassiae*, *U.* cf. *kungurensis*, *U. rumanus*, *Corbicula fluminalis*, *Pisidium jassiense*, *Dreissensia polymorpha*, *Neritina*, *Melanopsis* and also *Elephas trogontherii*, and many others. Equivalents of the terrace: the Ruedersdorf interglacial, the sands of Mountains Pivikha, Taburische, Kalitva and Borodayevka on the Dnieper, the Miussy beds of the Azov Seacoast and other deposits of the second (Great) Quaternary interglacial. The upper (ancient) level of the terrace (IVβ) has been drained towards the close of the interglacial (fossil eolian sands with *Helicogena lutescens*, *H. romatica* etc., buried under the Rissian loess). At the lower level of (IVα) lacustrine pre-Rissian loams have deposited at the same time, with *Planorbis planorbis*, *P. submarginatus*, *Gyraulus gredleri*, *G. albus*, *Paraspira leucostoma*, *P. spirorbis*,

Coretus corneus, *Radix auricularia*, *Galba truncatula*, *Bythinia leachi*, *Succinea oblonga*, etc.

The Grigoriopol stage (III). On the primitive Tertiary foundation coarse rubbles of the first phase of the third (Rissian or Dnieper) glaciation are lying. Higher up very thin river sands and alluvial cones of lateral valleys, corresponding to the short Rissian interstage. There are rare remains of elephants, rhinoceros, *Paludina sokolovi*, *P. zickendrathi*, etc. A normal alluvial series is absent. The valley, just issuing from the phase of intensive deep and lateral erosion (Rissian I), has been reverted to the initial erosion phase (Rissian II).

The Slobodzey stage (IIα and IIβ). At the base fluvioglacial rubbles of the closing stage of the Rissian glaciation are lying, covered by a rather thick alluvium with *Paludina fasciata*, *Bathyomphalus contortus*, *Planorbis planorbis*, *Valvata*, *Lithoglyphus*, *Neritina*, *Sphaerium*, *Pisidium*; remains of *Elephas primigenius*, etc. The time of deposition of the alluvium at the upper level (IIβ) comprises the third (Riss-Wurmian) interglacial; at the young level (IIα) the alluvium continued to deposit also during the Wurmian interglacial. Analogues: terraces with one (WII) or two (WI, WII) horizons of loess, widespread in the river valleys of the Ukraine.

The Parkan stage (I). The youngest of the series of the old Dniester terraces is devoid of a loess mantle. At the base of the terrace Wurmian rubbles are lying. The arenaceous alluvium is frequently blown from above. The beginning of accumulation of the alluvium is referred to the Bühl time; the formation of terraces has been completed during the Azil-Tardennoise epoch. Analogues: the horizon of arenaceous (Flanders) terraces of the Ukrainian rivers and of West Europe.

The flood plane or present-time terrace in the lower part of the river transgressively overlies the ancient terraces, covered by loess, and assimilates them.

The relative height of the old erosion and accumulative levels within the Podolian platform persists with a consistancy worth mentioning (the old Kuchurgan cover 200—220 m, the young gravel 150—180 m, the Kolkotov terrace 110—130 m, the Tiraspol terrace 70—90 m, the Grigoriopol terrace 30 m, the Slobodzey 15—20 m, the Parkan 7—8 m). Further to the south within the depression adjoining the Black Sea, the levels of the terraces approach one another, forming a terrace fan, whose convergent rays are directed towards the Black Sea.

Received
15. III. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GEOLOGY

PLIOCENE HYDROGRAPHY OF THE SOUTH UKRAINE*

By L. LUNGERSHAUSEN

(Communicated by A. A. Borissiak, Member of the Academy, 17. III. 1938)

The Aquitanian age in the middle course of the Dnieper and the Donetz, and the Upper Sarmatian time in the basins of the Dniester and the Bug, were marked by an important event—the recession of the sea and the establishment of continental conditions. At first a flat peripheral (coastal) plain little elevated above sea level did not favour a vigorous course of erosion, and the differentiation of the country advanced sluggishly. In spite of this, the hydrographic network, the origin of which in the more northern belt should be referred as early as to the Oligocene, during the Miocene time comprised a large area of the Ukraine, now extending far to the south and now reduced (at the periods of transgression). The character of the coast-line did not escape the influence of the erosional relief of the young land. It can be hardly doubted that it has been through the action of prolonged erosions strictly localized within definite zones that the depressions have been produced, at the place of which during the manifold alternation of Neogene transgressions bays and creeks were invariably forming. To those belong the Tiras (Galician), Borisphenian and Tanais (Maeotidian) bays. The age of these main lines of river erosion may be very old. The Neogene valleys used the old depressions produced by their remote predecessors. Probably, there is a succession the roots of which should be sought for in Paleogene and even at the close of the Mesozoic. Thus, the Tiras gutter, approximately corresponding to the present-day Dniester, may be referred either to the end of the Eocene or to the Oligocene; the Borisphenian depression and the wide trough of Tanais (the Azov Sea—the Don) in an embryonal form originated perhaps quite as early as the Mesozoic and during the later continental epochs directed the drainage of surface waters.

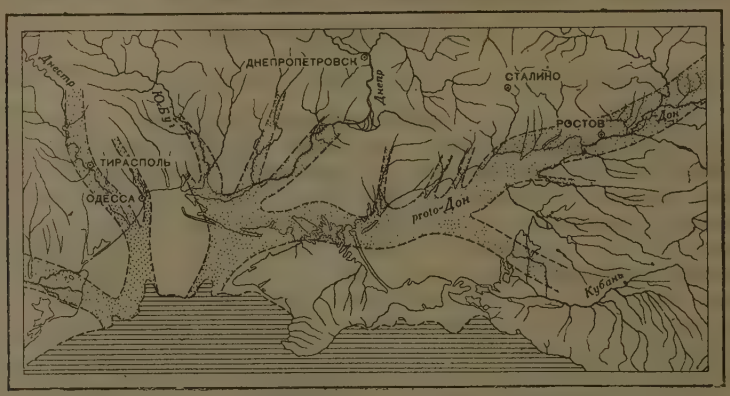
In the present paper the author will confine himself to the remarks made above and omit the oldest pages in the history of the river valleys.

It is all the more allowable since the relation between the Oligocene and Miocene valleys, as far as their outline may be discerned, and the present-day hydrography may be reproduced only with difficulty and in the most general features. The immediate subject of the author's discussion are phenomena of a different kind—chiefly patches of sands and pebblestones, original

* The conceptions presented in this note have been outlined by the author as early as the beginning of 1934 (Kiev State Univ. Transactions, new ser., v. I, fasc. 2, etc.); of late similar ideas have been advanced by M. M. Pukhtinsky and K. I. Makov working in the south of the Ukrainian SSR.

in their appearance and location, scattered along the northern coast of the Azov and Black Seas. Attempts at connecting these scattered islands of the old river sediments in some meridional systems (typical for the south of the Ukraine), i. e. to extrapolate them further inland, encountered considerable difficulties. The most frequently this complex shows an obstinate tendency to follow an almost latitudinal direction, ignoring the consequent ravines located with respect to this direction similar to the position of the lateral valley with respect to the main course.

The peculiarities of the bottom of the Azov Sea, the highly specific outlines of the sea shores with relicted forms of the old lateral ravines of drainage and the dividing ridges; a comparison of the morphology of the northern part of the Azov Basin with the low steppe adjoining the Sivash, inside which rests a thick (up to 30—35 m) bed of alluvial sands covered by a complete series of subareal Quaternary deposits and resting on eroded Pontian lime-



stones; a mental excursion further westward to the vast shallow water area of the Black Sea lying north of the line Tarkhankut-Dobrudja and bordered by a fringe of estuaries—all these brings us to a certain new conception which after a careful comparison of facts begins to appear as nearly obligatory and even as the only possible one. This new conception consists in assuming the existence of a vast river valley—proto-Don or Tanais which comprised the northern part of the Azov Sea, in the direction of Azov-Island Biryuchi, taking in from the left a great lateral branch—the pra-Kuban located in old gutters washed out during the pre-Cimmerian and somewhat shifted to the north with respect to the lower course of the present Kuban. At the place of the confluence of these two rivers, in spite of the powerful levelling influence of the later bottom deposits, the maximum depths of the sea are located, stretched in the direction of Tanais to the Taganrog Bay (E.N.E) and the direction of the pra-Kuban to Achuev (E.S.E), while to the west, i. e. along the course of the old river, a stem of constant depths is directed. On the right-hand side, descending from the edges of the crystalline massif, to the proto-Don discharges a whole system of short tributaries of a south-western direction. Probably, the Pliocene sands of the Molochnaya river, covered by clays and loess, in the base of which a tooth of *Elephas meridionalis* has been found, refer to this system. For the further westerly course of the stream we seek in the zone of the Sivash lakes and flat Askanian steppe. The bed of alluvial sands buried in its depths (also on the Changar) is an

evidence for the great size of the stream. Another evidence of this is the large latitudinal stretch of Pliocene alluvions. The presence in the valley of the Dnieper in the sands under a complete series of loess of a waterworn Cimmerian fauna (Dvoychenko and others), which has been up to now unaccountable for, is a brilliant proof of the existence of an old flow, directed from east to west, from the area adjoining the Azov Sea to the Dnieper. The northwestern corner of the Black Sea, to the 50th isobath, i. e. to the line Tarkhankut-Dobrudja, in the author's opinion is the southern wing of the continent, which carried the extremity of this old hydrographic system. In the relief of the sea bottom up to the present time wide ravine have been preserved, marking the course of the submerged river. It seems that running past the belt of the Sivash lakes, the Tanaic was bending to the southwest, following the outlines of the Karkanit Bay and discharging into the Black Sea at the latitude of 45°20'. To the left from it, not far from its mouth, flowed in the complicated system of the pra-Dnieper (Borisphen), comprising the Dnieper, Inguletz, Bug, Berezan and Tiligul. The Danube-Dniester fan was probably isolated from that of the Don-Dnieper (at some periods they could have formed one single system). The former connection of the Danube and Dniester is established by purely zoo-geographical data (A. A. Brauner) and existed in a not remote past. To more remote ages refers the development of some specific common features in the ichtyofauna of the Danube, Dniester and Dnieper (Kessel) as distinguished from the fauna of the Don. It was the moment when the Sivash link was already missing from the general chain and the system of the old Tanais fell into its derivatives: the eastern (Don-Azov) and western (Black Sea) systems.

The north-eastern continuation of the Tanais is not distinct. It is wholly hypothetical although quite probable to presume that at a certain geological moment the paleo-Volga (in its middle course) belonged not to the Caspian but rather to Euxenian Basin, and the proto-Don constituted only the closing (lower) link of the Volga-system. In later ages (especially during the intertransgressional phases, when the level of the Caspian was low) the young active river (the paleo-Lower Volga), restoring the course of its older predecessor of the epoch of the productive strata, could easily intercept the Middle-Volga portion and disconnect the systems of the Don and the Volga. Of especial interest from standpoint of the opinion expressed are the sands of the Ergheni which are hardly with sufficient grounds assigned by some authors to the Miocene or correlated with the sub-Akchagyl series of the Apsheron Peninsula. In their stratigraphical position, in the peculiarities of their occurrence, in their type the Erghenian beds should be considered as corresponding to the sands and pebblestones of Don with *Mastodon arvernensis*, and to the late Kuchurgan (and Kuchurgan?) cover of the Dniester.

The geological history of the proto-Don may be reconstructed only in the most general features. The first distinct erosions in the basin of this river refer to the pre-Pontian time. A more vigorous erosional phase should be assigned to the Middle Pliocene. Corresponding to it may be the river pebblestones and sands lying upon the eroded surface of the Pontian and older rocks. A course through the Sivash lakes at this epoch is the most probable, but has not as yet been proved. In the pre-Cimmerian time in the region of North Crimea and the area adjoining the Sivash lakes a meridional elevation took place disconnecting (later on) the eastern and western parts of the Cimmerian Sea. This elevation was preserved up to the Upper Pliocene time, constituting the natural western boundary to which the Akchagyl Sea extended. Probably, a southern threshold (Kerch to Taman) was its counterpart.

The next important phase in the development of the system of proto-Don comprised the Kuyalnitzk and post-Kuyalnitzk time. The fresh water-marine Kuyalnitzk deposits of the Odessa type are probably younger than the Akchagyl. Their distribution rather precisely inherits the shapes of the ancient river beds washed in the Middle Pliocene. At the same time at the divide of the Dniester and the Bug a mantle of old Kuchurgan gravel with Pliocene fauna was accumulated. A distinct erosional cycle refers to the moment immediately following the accumulation of the upper cover. Corresponding to this cycle is the late Kuchurgan ravine of the Dniester, the extensive erosions of the middle Dnieper and partly lower Dnieper, the erosional ravines in the lower course of the Don and Kuban, and finally the shaping of the great latitudinal trough: the Don—the Azov Sea—the Sivash lakes—the Karkinit Bay. The great thickness of the old alluvium filling this valley is an evidence that the time of its existence was a rather prolonged one. In the area of the Askania steppe a complicated network (primarily a consequent one) of gullies and small river valleies was formed, which later on, during the Quaternary time, were filled with loess, died out, owing to the high level of the basis of erosion, and converted to the remarkable water-pockets of the south. It may be presumed with certainty that the system of the old Tanais, as it is shown in the accompanying illustration, existed during the Upper Pliocene time, till the Chaudy time. Later on the way through the Sivash lakes was closed. The Don and the Dnieper acquired each an independent existence, although within the western (Black Sea) fan the connection between the separate branches (the Danube—the Dniester, the Dnieper—the Bug—the Berezan), being broken at periods of transgression, was maintained till a comparatively recent geological epoch.

Received
15. III. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

MINERALOGY

ON THE NUMBER OF MINERAL SPECIES

By A. E. FERSMAN, Member of the Academy

1. The question about the number of mineral species known in the earth's crust can be definitely solved only if a more precise definition will be given of the very idea of a «mineral species». M. Godlevsky (1) and A. G. Betekhtin (2) have been quite right in introducing a physico-chemical principle into the definition; they could not, however, avoid some difficulties in analysing disperse-colloidal systems and isomorphous mixtures. The classification of such multiphase systems should not be approached from a purely formal viewpoint, the more so that the mineral is a product of natural history and the most specific and complex systems are frequently quite normal to it. So much the more inadmissible would be a formal approach to the subdivision of isomorphous ranges into independent species and varieties.

2. The total number of mineral species is so inconsiderable that no particular practical significance should be attached to this question; it is important only to use the same conceptions, were it but arbitrary ones, in the analysis of natural phenomena.

According to the calculation made by O. M. Shubnikova (3), only 2177 out of 6759 names of minerals are referred to more definite species, and 1592—to varieties. Every year brings about 20—25 new mineral species (4, 5), so that the total number of species, within the accessible portion of the earth's crust, should not be estimated over 3000*, which number is very small in comparison with the vegetable and animal kingdom**.

The division into groups (6, 5, 7) shows that the number of combinations of rare elements (B, Be, Ge, Sc, Ti, Nb) has increased especially during the latter years.

Thus, the number of species is found to be strictly limited, the chief limitation of the number of combinations depending upon the character of distribution of chemical elements and the constancy of external conditions in certain regions of geochemical associations. A combination of these two factors results in a considerable reduction of the theoretically possible combinations of elements.

If only the first condition were observed, while the external factors were varying within a wide range, such a reduction would not take place. Meanwhile we know from geochemical data that the course of natural processes is regular, that even in the course of the primary cooling of magmatic hearths

* V. Vernadsky (1934) believes that the number of species will be as high as 6000 (1500 kinds of water included).

** R. Hesse (1929) shows that the number of animal species is about 1 000 000; Van-Tieghem (1918) gives 175 000 vegetable species.

a regular and strict distribution of elements takes place in connection with the proto-, meso- and telo-crystallization, and that in the prolonged process of common geochemical evolution the course of mineral formation is closely connected with the differentiation of elements. A number of elements does not reach the ultimate products, e. g. pegmatites of the granite magma, and if the penetration of a large quantity of nickel or cobalt into such a residual pegmatite were admitted, this would produce a number of new and peculiar mineral species.

The course of natural chemical reactions being regular, their types are few; this in turn leads to an isolation of chemical elements in definite areas, definite associations and under definite thermodynamic conditions, and all that leads to definite, regular and relatively few combinations of chemical elements, i. e. to a small number of mineral species.

We may with respect to definite geochemical complexes speak of «forbidden» elements and, consequently, forbidden combinations, e. g. vanadium and cobalt in granite pegmatites, antimony and arsenic in agpaites, lithium and beryllium in peridotites, etc. The prohibition of definite elements and their combinations, on the one hand, and a great constancy of certain associations of elements in their combinations, on the other, lead to a limitation of lattice types and of the number of mineral species.

But just as in physics the lines which are forbidden in earthly conditions become possible and real in cosmic bodies, owing to a peculiar character of scattering, so with regard to «forbidden» combinations, it is possible to imagine such «chance» and rare combinations of circumstances, when the prohibition appears practically removed, e. g. a granite pegmatite penetrates into a manganese deposit, a sulphide vein combines with a granite pneumatolite, etc.

It may be established, as a rule, that the largest number of new chemical combinations and new mineral species is due to superposition of different geochemical systems, repeated tectonic processes, overlapping of several geophases and types of tectonic and epeirogenic movements, and that the more uncommon is the combination of geological and geochemical phenomena, i. e. the more «forbidden» are these combinations, the greater will be the number of new compounds.

And, on the other hand, areas containing large numbers of new species, are at the same time areas where peculiar geochemical phenomena take place, and which are distinguished both by the complex of mineral bodies and the economic features; it is not without reason that the Longbahn, the Khibiny and the Belgian Congo, each one of them is a unique deposit of minerals, namely: Mn, Fe, Zn; P, TR, Mo, Al and U, Cu, Co, Pb, respectively.

3. The problem, however, will be still more interesting, if we examine the number of species in separate geochemical systems.

The following scheme may be proposed:

1) Very high temperatures (2000—5000°). The number of known combinations both according to experimental ([6]) and astrophysical data ([7]) . . . . . about 30

2) Temperatures of meteorite formation (1200—1600°). The number of solid and gaseous mineral species, well known (according to Farrington) . . . . . about 40

3) Temperatures of magmatic rock formation (1300—800°) (pegmatites not included). Number of species 120

4) Temperatures of granite-and nephelite-syenite pegmatite formation (800—350°). Number of species 400

5) Temperatures of pneumatolites and hydrothermalites (600—50°). Number of species 500

6) Hypergene temperatures (including 50° of grossans). Number of species* . . . 800

* Owing to the abundance of colloidal compounds and mutable combinations the calculation of the number of species is apporoximate. S. S. Smirnov ([9]) gives 500 species for heavy metals only.

This scheme is interesting in connection with the opinions on the subject given in literature: thus, I. Noddack and W. Noddack ([8]) connected the small number of species in meteorites, compared to that in the Earth, with the small size of that cosmic body, from which, probably, originated meteorites. V. M. Goldschmidt ([10]) opposes the view and point out that a large number of mineral species is due to they being isolated from aqueous solutions and magmas rich in water, and the difference is therefore determined by the character of the cosmic body and by its ability to retain volatile components in its external shell.

4. We may analyze this problem from the viewpoint of the energy of the process; the above table shows that the number of species increases with a decrease in energy of lattice formation, and that at highly elevated temperatures the small number of combinations corresponds to a very large range in the amount of emitted energy (as calculated to free ions); the compounds of high valencies, formed under these conditions with high EK and U, are practically few and simple as to structure and number of atoms (ions) in the molecule.

The thermal movements of atoms and ions, evidently, prevent the formation of more complicated structures. All the easier is the replacement of nodes in the lattices themselves by isomorphous and endocryptic admixtures.

As the temperature decreases, we pass to a region of considerably more closely spaced energetic levels; the possible combinations become much more various, the more so that numerous complex anions (with O or S) are formed with an ever increasing developing multiformity of their possible combinations. If the differences of lattice energy during the first high-temperature geophases of the process are measured by thousands of calories (50 Volts) to 1 mol. nevertheless in the hydrothermal processes the difference usually varies within 50—100 kg cal. (2—5 Volts); and finally, in the salt sediments of the earth's surface with simple and complex ions it is only 1—2 Volts. A further complication of the particles with a formation of double complex anions corresponds to alterations in the energy of the lattice less than of 1 el. Volt to 1 mol of the matter. Thus, it may be noted, for instance, that the energy of the lattice U for MgO =935 kg cal. and for NaCl only 180([11]).

It is quite clear that under the latter conditions there is a possibility of manifold combinations and that the complication of the molecule and its structure is of necessity associated with a little thermal effect of the crystalline lattice formation from free ions; a small alteration in the conditions of the balance of energy leads the combination into a new equilibrium system; simple ions, complex ions, double complex ions, heteropolycombinations, etc. are only individual steps in this way, which leads from mineralogical and geochemical processes into a new mobile region of biogeochemical reactions and artificial anorganic complexes; simple schemes chiefly of binary chemical compounds are replaced here by labile mutable equilibria of bertholites and a whole region of disperse colloidal microcrystalline systems of the earth's surface; this course of evolution is strictly regular from the viewpoint of energetics; it follows the general line of the increase of entropy.

In this way, the number of mineral species in different geochemical systems depends upon the thermodynamic character of these systems and the levels of their energy. Just as the persistance of the mobile systems of water and volatile components in a cosmic body results from its history, so the multiformity and complication of combining elements is a sequel of the whole historical course of development of the cosmic body.

It is evident that the peculiar complexity of mineral combinations is produced by the formation of complex anions.

If the interrelations between cations and anions were limited only to the existence of simple ion combinations, the list of minerals would be very short and the number of the minerals of the Earth would differ very little from the number of the minerals and combinations of meteorites. Only elements of water and, partially, H_2S in magmas and solutions produce a diversity of minerals, forming complex oxygen-anions first of all.

This explains the small number of mineral protocrystallization species in comparison with the final crystallization, especially the characteristical multiformity and abundance of species in alkaline pegmatites (in which the complex anions and heteropolyacids are especially abundant), the diversity of species of the closing geophases of crystallization of sulphide magmas [rich in [SH](11)] with their numerous but still unknown complex sulfosalts, etc.

Received
17. III. 1938.

REFERENCES

[1] М. Н. Годлевский, Зап. Мин. о-ва, LXVI, 107—111 (1937). [2] А. Г. Бетехтин, ibid., LXVI, вып. 3 (1937). [3] О. М. Шубникова, Тр. Ломон. ин-та Акад. Наук, X, 169—171 (1937). [4] О. М. Шубникова и Д. В. Юферов, Справочник по новым минералам, 1—168 (1934). [5] А. Е. Ферсман, Общий обзор новых минералов (в книге О. М. Шубниковой), 1—10 (1934); P. Tschirvinsky, ZS. Krist., **64**, 546—548 (1927); Riedenauer, ibid., **60**, 42 (1924); А. Е. Ферсман, Геохимия, III (1937). [6] H. Wartenberg, ZS. f. Elektrochemie, XXX, 351—356 (1924); O. Ruff, ibid., 356—364. [7] А. Е. Ферсман, Геохимия, II, 165—226 (1934). [8] I. Noddack u. W. Noddack, Svensk Kemisk Tidskrift, **46**, 173 (1934); ZS. f. angew. Chemie, **49**, № 1 (1936). [9] С. С. Смирнов, Зона окисления сульфидных месторожд. (1936). [10] V. M. Goldschmidt, Fortschritte d. Mineral., XIX, 185 (1935). [11] А. Е. Ферсман, Геохимия, III (1937).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

MINERALOGY

INTERGROWTH OF QUARTZ AND FELDSPARS FROM THE PEGMATITE VEINS OF KARELIA

By L. A. KOSSOY

(Communicated by A. E. Fersman, Member of the Academy, 15. III. 1938)

The graphic intergrowth of quartz and microcline are described. The intergrowths are regular and follow chiefly Fersman's adunchilog law; besides, a number of other regularities have been established, one of these being new. The gradual growth of ichthyoglypts betokens here the absence of eutectic relations.

So far the regularities of graphic intergrowths of quartz and feldspar have not been described for the pegmatite veins of Karelia. For this investigation several specimens of graphic pegmatite were taken from two pegmatite veins of the Sorok district. The veins present a medium-grained aggregate of microcline, oligoclase and quartz, with inclusions of porphyrocrystals of microcline, areas of graphic pegmatite, located mostly near zalbandes and small quartz pockets with feldspar relics (5).

Graphic pegmatite is peculiar in that in one specimen, i. e. in a piece of feldspar, intergrown by quartz ichthyoglypts, with the common quantitative proportions of constituents, the successive growth of quartz ichthyoglypts may be observed. This growth takes place to such an extent that the feldspar fills the interstices between the quartz segregations of a square and a different habitus.

A study of the alteration of ichthyoglypts by means of a number of parallel sections showed that the ingrowth of quartz pass gradually from angular skeleton-like formations with an empty middle to segregations of a similar external form, but larger in size and with a filled up middle.

Sometimes such structures with extensively developed quartz ichthyoglypts are transformed into compact quartz segregations.

These structures are like those described recently as apographic structures in different pegmatites of Siberia (3, 4, 6). But the latter are treated as recrystallization structures, secondary to the graphic structures. In our case, as may be well seen, all transitions from typical graphic structures to structures with extensively developed quartz ichthyoglypts may be observed.

The thin-sections showed that in cases of quartz growth each ichthyoglypt presents one crystal, and the orientation of the crystalline unit is constant with regard to feldspar.

Along the contact with quartz ingrowths the microcline is enriched in vein perthite ingrowths. Occasionally the quartz ingrowths are intersected by perthite ingrowths.

The laws of quartz and feldspar intergrowth have been studied in the following way. A number of parallel plates have been sawn out of graphic pegmatite, approximately perpendicular to the elongation of ichthyoglypts, and from these plates later on thin-sections have been made. For an interorientation of microcline and quartz it was necessary to plot on a plate two usual cleavages of microcline and the optical axis of quartz; this has been performed by means of the Fedorov stage on the Wulf plate ([7], [8]). After the determination of the optical indicatrix and, consequently, a determination of the cleavage plane indices, it was possible to perform proper rotation on the plate in such a way that the cleavages found coincided with those of the gnomostereographic projection of potassium feldspar. The attitude of the axis of the quartz ingrowths was then determined by itself.

The laws of intergrowth are summarized in Fig. 1. In this figure the gnomostereographic projection of the principal faces of monoclinic potassium feldspar is plotted. (The deviations of the crystallographic elements of microcline from orthoclase being small for the graphic method, they are not taken into account.)

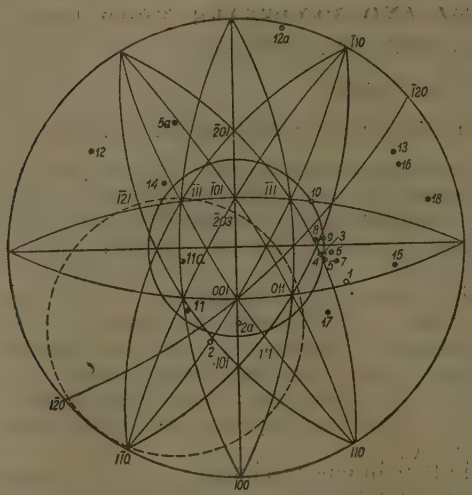


Fig. 1. Gnomostereographic projection of a monoclinic potassium feldspar. The axes of quartz ingrowths are marked by circles.

There are given also the optical axes of quartz ingrowth and the traces described by the optic axis of quartz when placing two adjoining faces of the rhombohedron in the center of the projection of the edge.

The ingrowths of quartz in microcline are represented by solid black circles, and the intergrowths of quartz and plagioclase from quartz pockets with feldspar relics, by open circles.

A study of the intergrowths shows that the chief-mass of the ingrowths is arranged according to the adunchilog right trapezohedral law of Fersman ([7], [8]). The measurements № 3, 4, 5, 6, 7, 8, 9 belong therein; of these № 3, 4, 5, 6, 7, 8 refer to all ingrowths of whole thin-sections, their wide significance is therefore beyond doubt; for № 9 differently orientated ingrowths were available in the thin-section.

As already known ([7], [8]), a coincidence of one of the trapezohedral quartz zones with the feldspar zone (Top) takes place in the adunchilog law.

According to the left law of Murzinka there is only one ingrowth № 10 (the coincidence of the prismatic quartz zone with the (Ttn) feldspar zone).

For the transition between the left law of Murzinka and the law of Rose (the coincidence of the M pinacoid of feldspar with the quartz prims) there is one case № 14, only this orientation of the ingrowths being manifested in the entire thin-section.

The ingrowth № 11 with sufficient accuracy coincides with the law first established by Gornostaev ([1]). It consists in the assumption that if one of the faces of the quartz rhombohedron coincides with the faces $(1\bar{1}0)$, $(1\bar{2}0)$, (011), $(\bar{2}03)$ $(\bar{1}\bar{1}1)$ or $(\bar{1}\bar{2}1)$, the remaining faces of the rhombohedron cover these faces.

The ingrowths № 12, 13, deviating to a certain extent, show a coincidence of the zone of the quartz prism with the zone (001), ($\bar{1}\bar{1}1$) of feldspar. Such an orientation is evidently stated for the first time.

For the ingrowths № 5a, 11a, 15, 16, 17, 18 the laws of their intergrowth with quartz has not been established, and their orientation may be regarded as accidental, though a coincidence of different zones of feldspar and quartz takes place, but with very irrational indices.

Drescher (2), who has essentially confirmed the laws of Fersman for graphic granites, also shows the presence of accidental ingrowths.

It will be noted that № 11a has been measured in the same thin-section, as № 11, and № 5a in the same thin-section as № 5, the angle between the axes is 90°.

The intergrowths of quartz with plagioclase from quartz pockets, marked in № 1, 2 and 2a, are evidently accidental.

Thus, a study of the graphic structures from the veins under description enables us to adopt the following points.

1. In the course of certain periods of vein-formation, more frequently during earlier periods, the conditions arise for a simultaneous growth of microcline and quartz.

2. These intergrowths are regular, the ingrowths of quartz are orientated definitely with regard to the crystallographic elements of microcline. In the instances shown the adunchilog trapezohedral law of Fersman predominates, though there take place the laws of Murzinka, Gornostaev and a new law too.

3. During the growth the quantity of the components varies, the quantity of quartz being increased to a complete disappearance of microcline and a passing to a quartz pocket.

4. The conception «eutectic» is inapplicable to these intergrowths since a constancy of relations is absent here.

5. Non-orientated ingrowths are encountered.

6. Intergrowths of quartz with plagioclase relics from quartz pockets are accidental, for which reason they may be regarded with a greater probability as erosion structures.

7. The vein perthite is eroding the quartz ingrowths.

The Scientific Research Institute
of the Earth's Crust.
Leningrad.

Received
17.III.1938.

REFERENCES

[1] Н. Н. Горностаев, Изв. Томск. техн. ин-та, **46** (1924). [2] Drescher, Fortschr. M. K. P., **161** (1931). [3] С. П. Коноплев, Пегматиты Бирюсинского района (1937). [4] Д. С. Коржинский, Сб. «Слюды СССР» (1937). [5] Л. А. Косой, Тр. Л. Г. У. [6] Н. В. Петровская, Гиганто-магматитовый тип пегматитов Мамско-Витимского слюдоносного района (1937). [7] А. Е. Ферсман, ИМЕН, VI, № 12 (1915). [8] A. E. Fersman, ZS. f. Krist., **69**, H. 1—2 (1929).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GENETICS

GENETICAL AND CYTOLOGICAL ANALYSIS OF LETHALS IN *DROSOPHILA* ARISEN IN NATURE

By R. A. MASING

(Communicated by N. I. Vavilov, Member ob the Academy, 14. III. 1938)

Many workers have demonstrated in recent years that the genetic nature of lethal mutations is very diverse. According to Oliver ([4]), Patterson ([5]), Demerec ([1]) and Sacharov ([6]) the influence of X-rays produces mainly lethal mutations of the type of chromosomal aberrations. Both under the influence of chemicals and spontaneously under laboratory conditions arise, as shown by Sacharov ([7], [8]), only point-lethal mutations. On account of the sharp difference between the nature of the lethals which arise under the influence of X-rays and those produced by chemicals or occurring spontaneously, Sacharov makes an interesting suggestion, namely, that the said difference is probably caused by the difference of the mutational action of X-rays and of those factors which cause the normal process of mutation. While admitting that Sacharov's suggestion is fully correct, we nevertheless must point out that Sacharov studied lethals which were arising spontaneously under laboratory conditions, the latter being hardly normal for *Drosophila*. It should be added, moreover, that all the studies devoted to the nature of the lethals are concerned with the sex-chromosome in which lethals are known to occur but rarely under natural conditions.

Dubinin and others ([2], [3]) have demonstrated that in the majority of natural populations the autosomes are exceedingly rich on lethals; this probably should be explained by the fact, that lethals which arise in autosomes are maintained and may even accumulate in heterozygous condition. In some of the populations the concentration of lethals was as high as 21.4%, although their nature remained unknown.

In connection with the above said it seemed to be of interest to study the nature of lethals and semi-lethals which arise under natural conditions.

We have chosen lethals and semi-lethals in the II chromosome of *Drosophila melanogaster*, which were found in populations from various geographic regions of USSR; thanks are due to M. E. Lobashev, J. D. Muretov, S. A. Philipchenko and O. V. Ostapenko of the Laboratory of Genetics of Animals of the Leningrad University, who turned over the material to us as well as the data on the identification of lethals.

Table 1 shows the geographic origin and the number of lethals and semi-lethals* studied.

* The nature of semi-lethals is wholly unknown as yet (they were studied by us in the Laboratory of Genetics of Animals of the Leningrad University).

Seventy non-identical lethals and seventy-six semi-lethals were analyzed for translocations with the aid of the line *y bw e ey*. Cytologically by the method of Painter were studied seventy lethals and thirteen semi-lethals. Fifty-one lethals were localized genetically.

Genetic analysis for translocations was conducted parallel to cytological investigation inasmuch translocations involving whole chromosome-arms could be overlooked cytologically.

Table 1

Locality (origin of the population)	Genetically studied for translocations		Studied after the method of Painter		Localized after the method of dominants
	lethals	semi-lethals	lethals	semi-lethals	lethals
Tashkent	26	30	26	6	15
Merv	6	12	6	5	6
Frunze	6	9	6	—	5
Alma-Ata	5	4	5	1	4
Andijan	9	11	9	—	7
Kuibyshev	18	10	18	1	14
Total	70	76	70	13	51

Not a single case of translocation was discovered which falls in line with the data by Goldat [see Dubinin (3)], who has demonstrated the absence of translocations in nature.

For studying chromosomes after Painter in the nuclei of the salivary glands of larvae of *Drosophila* males $\frac{Cy}{l}$ were crossed with females *ebony*, and nuclei of the larvae were analyzed for *Cy* (larvae possessing lethals in heterozygous condition were chosen; *Cy* has in both arms of the chromosome inversions which are easily distinguishable in the nuclei of the salivary glands). Females *ebony* were introduced into crosses for the sake of additional check of the virginity of the females used; therefore, cultures which furnished larvae were not discarded but were looked through as the flies hatched.

Despite the most careful study of the chromosomes in salivary glands we could not succeed in discovering a single case of chromosomal aberration; all the lethals and semi-lethals should be considered, therefore, as being point-mutations. Only most insignificant changes within one or two disks could be overlooked, since the lethals were not previously localised and we had to study the two chromosome-arms from one end to the other. However, the uncertain chromosome-regions were recorded and were again checked in salivary glands when the locus of the lethal proved to be coincident with the region recorded. Repeated analysis proved the correctness of our conclusion on the point-nature of the lethals.

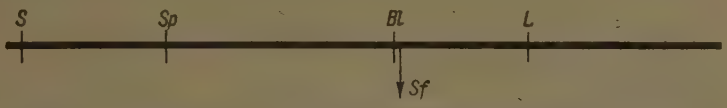
Inasmuch as all the 70 lethals and the 18 semi-lethals proved to be point-mutations, further analysis of semi-lethals was discontinued.

The presence of a large number of lethal point-mutations made it possible to clear up the character of their distribution along the chromosome. They were located in each arm separately with the aid of lines containing dominant mutations *SSp* and *BlL*[2]*.

* The attempt to synthesize the line $\frac{SSp\ BlL^2}{Cy}$ failed as *S* is indiscernible in the presence of *L*.

In order to determine the location of the lethal flies non-Cy were counted which were obtained from crossing $\frac{l}{Bl\,L^2}$ with $\frac{l}{Cy}$. Flies Cy were studied in order to find out whether any aberration in crossing-over takes place; in no case, however, was crossing-over disturbed. When the lethal was present in the left arm, it was localized with the aid of the line $\frac{SSp}{Cy}$.

Table 2



to the left S	region S	between S a.Sp	region Sp	between Sp Bl	region Bl	between Bl a.L	region L	to the right L
1	5	5	2	5	18	7	—	8

In Table 2 are given the data bearing upon the location. Except for the accumulation in the region Bl lethals were distributed along the chromosome rather uniformly (disregarding the rather strange absence of lethals in the region L). Accumulation in the region Bl wholly corresponds to a similar accumulation of visible mutations on the genetic map which probably should be explained in the two cases by abnormalities of crossing-over in the given region of the chromosome and not by an actual condensation of mutations.

Lethal point-mutations in the sex-chromosome, studied by Sacharov ([7], [8]), are also distributed rather uniformly; however, inasmuch as he studied lethals in the sex-chromosome he was able to locate them with considerably greater precision, which hinders the comparison of our data on the II chromosome with those by Sacharov on the sex-chromosome.

The fact that all the natural lethals studied by us proved to be point-mutations seems to be of great significance. Our data fully confirm the idea of Sacharov on the difference in the mutational effect of the natural factors and that of the X-rays; great caution should be therefore applied to general conclusions on the nature of the process of mutation when such conclusions are based upon study of mutations produced by X-rays.

Laboratory of Genetics.
Department of Nervous Diseases.
Kirov Institute for Qualification
of Physicians.
Leningrad.

Received
16. III. 1938.

REFERENCES

[1] M. Demerec, Amer. Natur., **69** (1935). [2] Н. П. Дубинин и др., Биол. журн., III, вып. 1 (1934). [3] Н. П. Дубинин и др., Биол. журн., V, вып. 6 (1936). [4] C. P. Oliver, ZS. Ind. Abst. Vererb., **67** (1932). [5] P. T. Patterson, Amer. Natur., **66** (1932). [6] V. V. Sacharov, C. R. Acad. Sci. URSS, IV, № 1—2 (1935). [7] В. В. Сахаров, Бюлл. экспер. биол. и медиц., I, вып. 3 (1936). [8] В. В. Сахаров и В. А. Науменко, Бюлл. экспер. биол. и медиц., II, вып. 2 (1936).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GENETICS

PHYSIOLOGICAL STERILITY IN THE CULTIVATED COLUMBIAN POTATO *SOLANUM RYBINII* JUZ. AND BUK.

By L. N. KOKHANOVSKAYA

(Communicated by N. I. Vavilov, Member of the Academy, 14. III. 1938)

A serious difficulty in hybridization which the potato breeder encounters, is sterility in many varieties of *Solanum tuberosum* and wild species of potato, many of which have economically valuable characteristics.

Among the new species collected by expeditions of the All-Union Plant-Breeding Institute in 1925—1932 (Bukasov, Yuzepchuk, Vavilov) we find frost-resistant (*acaule*, *curtilobum*, *ajanhuiri* and others), early-ripening (*Rybinii*, *phureja*, *chaucha* and others), resistant to phytophthora (*Antipoviczii* and others) species, and so on. However, except fot the *acaule* and *Antupoviczii*, all of the above species do not as a rule produce berries.

In his review of the kinds of sterility in potatoes Clarc (1) reported two kinds of sterility in cultivated varieties: 1) sterility due to the absence of efflorescence and the premature dropping off of buds and blossoms, and 2) sterility of the pollen. On the other hand, the wild species of potato are characterized by the sterility of the pollen and physiological sterility or self-incompatibility (according to Stout's terminology). According to Clarc, two wild species of potato—the *Solanum Caldasii* var. *glabrescens** and the *Solanum chacoense*—are self-incompatible to a high degree. The physiological sterility has not yet been established exactly for cultivated species of potatoes, although slight variations in the degree of self-incompatibility have been noticed in them.

One of the primitive species (24 chromosomes) was the subject of the present investigation—the *Solanum Rybinii* Juz. and Buk. (2). It is a cultivated Columbian mountain species, resistant to virus diseases. It is different from all other species of tuberous *Solanum* in the absence of a period of rest (tubers germinate immediately after they are dug up). According to Bukasov (3) it crossbreeds with most of the known species of the *Tuberarium* section (*S. andigenum*, *goniocalyx*, *phureja*, *tuberosum*, and others).

Having the characteristics mentioned above, the *S. Rybinii* is one of the most important primitive species of potato from the point of view of selection. As a rule, it does not produce berries through self-pollination.

It was the aim of this investigation to establish the embryological picture of the phenomenon of sterility in the *S. Rybinii*. For this purpose we made an embryological examination of the embryo sac and the behaviour of the pollen tubes in the pistil tissues on self-pollination of the *S. Rybinii* and on its pollination with pollen of the *S. goniocalyx*.

* Clarc seems to have dealt with one of the species belonging to the *Solanum Parodii* Juz. and Buk.

Material and Methodology. The material for examination was grown in the hotbeds of the Arctic Branch of the All-Union Plant Breeding Institute (in Khibiny, Kola Peninsula) in 1934, and on the experimental plot of the Physiological Laboratory of the All-Union Plant Breeding Institute in Pushkin, near Leningrad, in 1936. Large buds (about two days before the blossoms were going to open) were castrated and placed in parchment bags. Fixation took place at various times: 3, 6, 9, 12, 24, 48, 96, 120 and 144 hours after pollination. The pistils were fixed according to Navashin, Lang and Buen methods. Staining with ferrous haemotoxylin according to Heidenhain and a triple staining according to Flemming were usually applied.

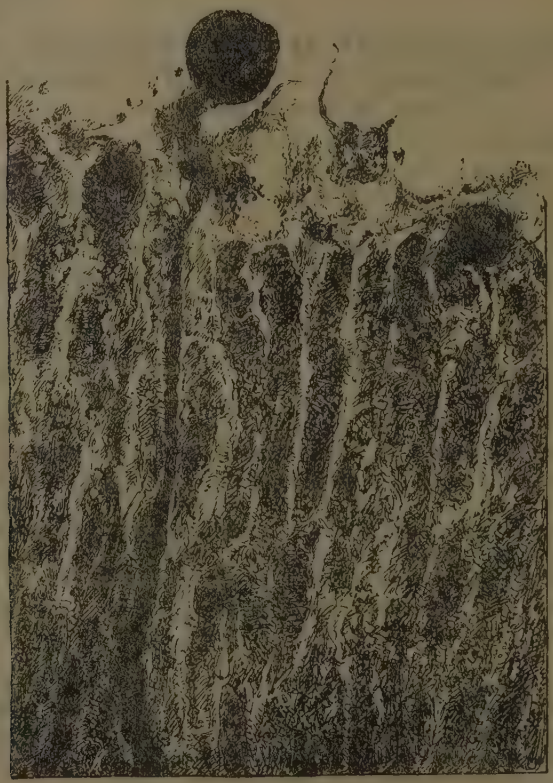


Fig. 1. Pollen tube of the *Solanum Rybinii*, growing into the tissue of the stigma during self-pollination (Apo 90, K 7 x).

The indicated methods of fixation and staining gave good results. Fixation after Buen, with subsequent staining with ferrous haematoxylin, proved to be especially suitable for the embryo sac. The fixed material was treated in the usual way. The microsections of styles and ovaries were made with a microtom (thickness of the cuts of style was 14 μ, of an ovary, 12 μ).

Examination of the Embryo Sac and of the Course of the Pollen Tubes in the Pistil Tissues. Microscopic examination showed that the embryo sac of the *S. Rybinii* is formed typically for the *Solanaceae* and that the pollen of the *S. Rybinii* is

morphologically perfect. It grows well in a moist chamber on artificial medium (saccharose, 15 g; agar-agar, 1 g; distilled water, 100 cm^3).

Under observation, three hours after the pollen of *S. Rybinii* was introduced into the stigma, it was found that the pollen grains began to form pollen tubes. A large part of the pollen tubes grew into the tissue of the style (Fig. 1). In a large number of preparations it was seen that the pollen tubes of the *S. Rybinii* grew into the tissues of their own style slowly. Twenty-four hours after pollination their main part was found in only one fourth of the style. Here numerous pollen tubes terminated their growth, forming widened ends and knob-shaped swellings (Fig. 2). Pollen tubes that had seemingly burst were also observed. Occasional pollen tubes reached the base of the style and then usually did not grow furhter.

Fig. 2. Pollen tube of the *Solanum Rybinii* which has formed a swelling in the tissue of the style during self-pollination (Apo 90, K 7 x).

Fig. 3. Pollen tube of the *Solanum goniocalyx* (*S. Rybinii* × *S. goniocalyx*) between the placenta and seed embryos (Apo 90, K 7 x).

During pollination of the *S. Rybinii* with pollen of the *S. goniocalyx*, after the same lapse of time, that is, 24 hours after pollination, the pollen tubes of the *goniocalyx* were already in the cavity of the ovary between the placenta and the seed embryos (Fig. 3). In many hundred sections of styles of the *S. Rybinii*, which were fixed five days after being pollinated with their own pollen, it was found that the pollen tubes were located at the base of the style. By that time (five to six days after blossoming of the flower), the corolla wilted and the embryo sac degenerated.

Thus, it must be admitted that sterility of the *S. Rybinii* refers to the type of physiological sterility which is widespread among most different taxonomic groups and has been well studied genetically. As is known, it is characteristic of this type of sterility that plants, which possess normally developed and functionally capable pollen grains and egg cells, are not able to produce seeds through self-pollination.

It should be noted that the degree of self-incompatibility can vary according to the external conditions. A number of authors point out this. Thus,

Stout ([4–7]) has found this dependence to exist for the *Cichorium Intybus* (all gradations from complete sterility of plants to their complete fertility are present in *Cichorium*); Brink ([8]), for the *Melilotus officinalis*.

Slackening and cessation of the growth of the pollen tubes into the tissue of the style during self-pollination does not occur in the *S. Rybinii* in every case without exception. The *S. Rybinii* has a prolonged efflorescence. Under the conditions prevailing in Leningrad province just as under those on the Kola Peninsula (in Khibiny), it blossoms from the second half of July until the first autumn frosts. At the end of the vegetative period, in the beginning of August and September, cases of the formation of berries were noted in Krasny Pakhar, Pushkin and in Khibiny.

The author examined the pistils of the *S. Rybinii*, fixed Aug. 24, 1934, in Khibiny, three days after artificial self-pollination. In the preparations that were obtained the pollen tubes were found in the ovary cavity between the seed embryos. In some embryo sacs the first division in the endosperm was already observed. Thus fertilization through self-pollination took place here at the end of the vegetative season, a phenomenon which East and Park ([9]) have named «pseudofertility».

Nevertheless both in Leningrad province and on the Kola Peninsula the *S. Rybinii* forms only occasional berries at the end of the season. According to Perlova ([10]), more considerable berry-formation is observed with the *S. Rybinii* in the Pamirs (near the city of Kharog, 2320 above sea-level), also at the end of the vegetative period.

Attempts to achieve heterogenesis of plants by means of giving them different kinds of mineral food, as was done by Korzhevin ([11]) in his work with *Veronica Chamaedrys*, and also by their cultivation with various lengths of the day for the purpose of overcoming physiological sterility have not given favourable results.

Thus: 1) We have established physiological sterility (self-incompatibility) in the cultivated Columbian potato, the *Solanum Rybinii* Juz. and Buk.

2) The slow growth of the pollen tubes and the cessation of this growth in the tissues of the style are the direct cause of self-incompatibility in the *S. Rybinii*.

3) Self-incompatibility in this species is well expressed from the beginning to the middle of efflorescence. At the end of efflorescence (which coincides with the end of the vegetative period) cases of pseudofertility were observed in it, just as in other self-incompatible plants. Under the influence of changed external conditions the rate of growth of the pollen tubes increases. Some of them fall into the cavity of the embryo sac and cause fertilization. The formation of berries at the end of the season has been observed in Krasny Pakhar, in Pushkin (Leningrad province), in Khibiny (Kola Peninsula), and especially in the Pamirs.

Laboratory of Physiology.
All-Union Plant-Breeding Institute.
Pushkin.

Received
17. III. 1938.

REFERENCES

[1] C. Clarc, Mem. Hort. Soc., N. Y., **3**, 289—294 (1927). [2] С. М. Букасов, Прилож. 47 к Тр. прикл. бот., ген. и сел., 213—214 (1930). [3] С. М. Букасов, Теор. осн. селекц., III, 3—76 (1936). [4] A. B. Stout, Mem., N. Y. Bot. Gard., **3**, 333—455 (1916). [5] A. B. Stout, Amer. J. Bot., **4**, 375—395 (1917). [6] A. B. Stout, J. Genet., **7**, 71—103 (1918). [7] A. B. Stout, J. Genet., **9**, 85—129 (1920). [8] R. A. Brink, J. Amer. Soc. Agr., **26**, 4, 307—313 (1934). [9] E. M. East and J. B. Park, Genetics, **2**, 505—609 (1917). [10] R. L. Perlova, Amer. Potato Journ., **8**, 217—220 (1937). [11] В. С. Коржевин, Изв. Гл. бот. сада СССР, XXVII, вып. 3, 340—349 (1928).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GENETICS

INHERITANCE OF BIOCHEMICAL CHARACTERS IN ANIMALS IN CONNECTION WITH GROWTH

By V. I. PATRUSHEV

III. ON SOME INDICES OF THE BLOOD COMPOSITION OF THE HYBRIDS BETWEEN BACTRIAN CAMELS AND DROMEDARIES IN CONNECTION WITH HETEROSIS

(Communicated by N. I. Vavilov, Member of the Academy, 28. II. 1938)

Introduction. Owing to the fact that blood is directly involved in all basic processes of metabolism, the study of its characteristics makes it possible to judge of the intensity of metabolism and the productivity of the organism connected with the latter (4). The study of haematological differences between animals showing hybrid vigour and normal ones may supply interesting material bearing upon the relation between the biochemical characters of animals and their growth and productivity.

Studies of the mechanism of manifestation of heterosis are urgently needed for finding out its nature and for working out the problem of fixation of the hybrid vigour in subsequent generations.

Investigation is, finally, useful since the available data on normal composition (haemogram) of the blood of camels are very scarce (2, 9, 14, 15).

Scope and Method of Work. We have studied the blood composition altogether of 100 animals coming from the camel-farm № 125 (South Kazakhstan), and among them: 28 nars (hybrids between bactrian camels and dromedaries), 20 dromedaries, and 52 bactrian camels.

The work was done in October 1937. At the moment of investigation the animals grazed on half-desert pastures and proved to be of medium or above medium stoutness.

Blood was taken from the jugular vein in the morning before the animals were watered and sent to grass.

The study included the volume of the formed elements of the blood, resistance of the erythrocytes, specific gravity of the blood, total and reduced glutathione content, activity of catalase. Another worker investigated in the same animals the amount of erythrocytes, the size of the erythrocytes, the haemoglobine content and the reserve alkalinity of the blood (7).

The indices enumerated above give a rather full idea of the characters of the red blood; this is why they were chosen as criteria of the metabolic activity in bactrian camels, dromedaries and nars (12). The reasons for such a choice were presented in our earlier works (10, 11).

The volume of the formed elements was studied by means of precipitation of oxalated and citrated blood during twenty-four hours in Sahli test-

tubes. Checking this method has shown that it gives only relative values of the indices owing to imperfect precipitation of erythrocytes during 24 hours.

Resistance of Erythrocytes. According to medical and veterinary data [12] young erythrocytes are less resistant and suffer haemolysis in considerably higher concentrations of salts, while the old ones are destroyed only by low concentrations. There exist, besides, specific differences in osmotic resistance of erythrocytes [16]; study of this index is, therefore, of certain interest. Resistance of the erythrocytes was determined macroscopically in test-tubes after Vidal.

Specific gravity of the blood was determined with the aid of ordinary picnometers, they were filled with blood to the external opening in the stopper [12]. Glutathione was determined after the method of Woodward and Fry [3]. Catalase was determined after Bach [1].

Description of the Material. In order to characterize the animals investigated, Table 1 is added.

Table 1

Dynamics of the Live Weight of Camels

Age groups	Bactrian camels			Nars		
	n	*M*	lim	*n*	*M*	lim
At bearth	14	42.8	34— 47	11	46.3	37— 60
3 months	13	139.0	115—175	11	166.3	130—219
6 »	13	201.0	129—231	10	237.9	165—275
9 »	6	214.6	206—230	5	267.0	231—307
12 »	6	260.5	230—305	5	326.4	265—417
15 »	6	383.3	356—424	5	419.0	324—495
18 »	—	—	—	5	465.6	405—550
Born in 1935—2.5 years old	—	—	—	3	623.0	589—655

The dromedaries investigated scarcely surpass the bactrian camels in height measured to withers (173.2 ± 4.4 and 172 ± 1.46); they are, however, flatter and lighter compared to bactrian camels. Thorax-circumference in dromedaries is from 7 to 8 per cent less than in bactrian camels ($205.4 + 1.94$ and 220.9 ± 2.99). Live weight of adult bactrian camels on the average exceeds that of dromedaries for 45 kg (621.4 ± 16.7 and 666.2 ± 21.6).

It should also be noted that dromedaries are distinguished from bactrian camels by higher animal spirits.

Hybrids of the first generations—nars—display a clearly pronounced heterosis with regard to the basic morphological indices. They exceed the two parental forms in live weight, height of withers, thorax-circumference, etc., and are more inured to weariness.

When these data are compared with those contained in literature [2, 5, 8], it is possible to draw the conclusion that the animals investigated by us are typical for the conditions of Kazakhstan.

The results of the investigation of the blood are summarized in Table 2. It contains no data on the resistance of the erythrocytes since only isolated age- and species-groups were studied. Data on the total glutathione are not different from those on the reduced glutathione.

Let us analyze first each component separately.

Volume of the Formed Elements. Variation of the volume of the formed elements with the age was studied in nars. It may be seen from Table 2 that the formed elements are decidedly reduced with the age.

On account of lack of data on the variation with age of the character in question in dromedaries and bactrian camels, we have to compare them in adult animals. Our data show that there are no specific differences in the volume of the formed elements; however, hybrids possess a higher quantity of formed elements as compared with the parental species.

Resistance of Erythrocytes. The resistance of the erythrocytes when studied at different ages appears to grow with the age both in bactrian camels and in nars, though insignificantly. In other words, the erythrocytes are osmotically more stable in adults than in the young. Small differences in the resistance between nars and parental forms should also be mentioned. Thus, erythrocytes of the six months old nars undergo haemolysis in 0.31—0.39% solution of NaCl, while the erythrocytes of bactrian camels of the same age are destroyed in lower concentrations (0.30—0.37 per cent), i. e. are more resistant.

Higher resistance of the erythrocytes of nars as compared with the bactrian camels was found also in 1.5 and 2.5 years old animals. Comparison of adult nars with adult dromedaries shows that erythrocytes of nars are more resistant to the destructive action of low concentrations as compared to the erythrocytes of dromedaries.

Reduced and Total Glutathione Content. Variation of the reduced and total glutathione content with the age is on the whole similar in nars and bactrian camels (Table 2). Following an increase in glutathione content up to the age from 2 to 2.5 years, a slight decrease of it sets in. With regard to glutathione content nars occupy the first place (26.4%), dromedaries—the second (25.4%), and bactrian camels—the last (23.2%). Analogous results were obtained by us for the total glutathione. The only exception represent six months old nars in which somewhat lower content of reduced glutathione was found.

Specific Gravity of the Blood. The specific gravity of the blood constantly increases with the age in bactrian camels and in nars.

Among adult animals nars possess the highest specific gravity of blood (1.0736), then follow the dromedaries (1.0672) and the bactrian camels (1.0664).

Activity of the Catalase. The activity of the catalase in the blood of camels has a tendency to decrease with age.

Class differences were noted in young bactrian camels and nars. The activity of the catalase proved to be considerably higher in the blood of bactrian camels than in the blood of the nars. In adult animals these differences are less pronounced; the activity of the catalase proved to be the least in the blood of the dromedaries.

Comparison of the indices of catalase in the blood of nars and dromedaries falls in line with data on the incomplete dominance of the low catalase index as established for a series of animal and plant species ([6] and others).

Biometrical significance of differences in indices of blood is shown in Table 3.

Conclusions

1. The volume of formed elements is higher in the blood of hybrids as compared with the original formes. The volume of formed elements of the blood decreases with age.

Groups of Animals		6 months old (1937)			1.5 year old (1936)		
		n	*M* ± *m*	lim	*n*	*M* ± *m*	lim
Reduced glutathione	Bactrians ♀♀	8	22.8 ± 0.9	18—33	6	21.27 ± 1.2	16—25
	Dromedaries ♀♀	—	—	—	—	—	—
	Nars ♀♀	7	21.3 ± 1.3	17—27	4	25.9 ± 2.5	19—31
Volume of formed elements	Bactrians ♀♀	—	—	—	—	—	—
	Dromedaries ♀♀	—	—	—	—	—	—
	Nars ♀♀	3	82	75—90	5	77 ± 3.4	70—90
Specific gravity	Bactrians ♀♀	8	1.061 ± 0.0046	$\frac{1.0474}{1.0865}$	5	1.0625 ± 0.005	$\frac{1.0545}{1.0825}$
	Dromedaries ♀♀	—	—	—	—	—	—
	Nars ♀♀	6	1.0638 ± 0.0038	$\frac{1.0541}{1.0743}$	5	1.0634 ± 0.004	$\frac{1.0541}{1.0779}$
Catalase	Bactrians ♀♀	6	8.22 ± 0.5	6.97—10.03	4	8.07 ± 0.19	7.48—8.33
	Dromedaries ♀♀	—	—	—	—	—	—
	Nars ♀♀	4	4.23 ± 0.17	3.74—4.59	5	3.74 ± 0.1	3.57—4.25

Table 3

Probabilities of Differences of the Blood Indices in Camels

Indices	6 months		1.5 year		2.5 years		Adults	
	bactr. / nars	*P*, %	bactr. / nars	*P*, %	bactr. / nars	*P*, %	bactr. / nars	*P*, %
Reduced glutathione	b > n	66.4	n > b	86.7	n > b	66.1	n > b	72.9
Total glutathione	n > b	37.3	n > b	64.8	n > b	83.0	n > b	38.3
Specific gravity	n > b	30.3	n > b	7.7	n > b	90.1	n > b	91.1
Resistance to haemolysis	n > b	49.8	n > b	95.9	n > b	86.2	n > b	99.7
Resistance to precipitation	n > b	77.4	n > b	86.4	n > b	95.3	n > b	94.3
Catalase	b > n	100.0	b > n	100.0	b > n	99.7	b > n	95.4
Volume of the formed elements	—	—	—	—	—	—	n > b	57.6

Note: b—bactrian camels, n—nars.

vestigation in Camels

Table 2

2.5 years old (1935)			Adults					
n	$M \pm m$	lim	n	$M \pm m$	lim	$\pm \sigma$	cv%	lim
10	24.2±1.67	22—27	24	24.2	0.75	3.62	14.9	14—30
—	—	—	18	25.4	0.9	3.33	14.8	17—30
3	27.74±2.9	22—32	10	26.4	1.84	5.52	20.9	16—35
—	—	—	24	72.3	0.87	4.18	5.7	64—80
—	—	—	20	72.45	1.31	5.42	7.5	55—80
3	80.7	80—82	12	74.0	1.91	6.44	12.3	58—83
10	1.0640±0.0034	$\frac{1.0532}{1.0832}$	19	1.0664	0.0023	0.00984	0.92	$\frac{1.0541}{1.0866}$
—	—	—	17	1.0672	0.0027	0.01088	1.0	$\frac{1.0526}{1.0885}$
4	1.0696±0.009	$\frac{1.0633}{1.0847}$	10	1.0736	0.0037	0.01114	1.0	$\frac{1.0580}{1.0903}$
11	7.90±0.7	3.40—12.68	21	4.85	0.4	1.78	36.8	2.89—8.33
—	—	—	18	3.70	0.18	0.76	20.6	1.87—5.10
4	4.50±0.2	4.25—5.20	13	3.98	0.19	0.68	17.2	3.06—5.10

2. The specific gravity of the blood is the highest in hybrids. Dromedaries assume the second place, and bactrian camels—the third. The specific gravity of the blood increases with age.

3. The total and reduced glutathione content is higher in hybrids than in original forms. Dromedaries assume the second place, bactrian camels—the third one.

4. Erythrocytes are the most resistant in bactrian camels; then follow the erythrocytes of nars and those of dromedaries.

5. The catalase content is the highest in the blood of bactrian camels, and the lowest in the blood of dromedaries. Catalase content in the blood of nars is somewhat higher than in that of the parental forms which is poorest on this component.

6. Heterosis in nars, as expressed in height, size and hardiness, may be conditioned, along with other causes, by an increased volume of the formed elements of the blood, by an increased glutathione content and higher concentration of the blood of the hybrids (as expressed in higher specific gravity), compared to the parental forms.

Received
11. III. 1938.

REFERENCES

[1] A. Bach u. S. Zubkowa, Biochem. ZS., **125** (1921). [2] А. П. Бергрин, В. В. Петропавловский и др., Верблюдоводство (1934). [3] G. Woodward a. E. Fry, Journ. of biol. Chem., **97** (1932). [4] П. Дюрст, Основы разведения крупного рогатого скота (1936). [5] В. Н. Колпаков, Журн. научн. и практич. ветер. и мед., X, вып. 3 (1928). [6] Н. К. Кольцов, Содержание каталазы в крови позвоночных как наследственный признак. [7] H. F. Kushner, C. R. Acad. Sci. URSS, XVIII, № 9 (1938). [8] К. К. Лакоза, Коневодство, № 12 (1931). [9] М. А. Малышев, Журн. научн. и практ. ветер. и мед., X., вып. 3 (1928). [10] V. I. Patrushev, C. R. Acad. Sci. URSS, XIV, № 9 (1937). [11] V. I. Patrushev, ibid. [12] В. Н. Предтеченский и др., Руководство по лабораторным методам исследования (1936). [13] К. И. Путилина, Журн. эксперим. биол., V, вып. 1 (1929). [14] Н. А. Сычев, Журн. эксперим. биол., VI, вып. 1 (1930). [15] Фролов, Тр. ГИЭВ, V, вып. 2 (1928). [16] В. Эллербергер и А. Шейнерт, Руководство по сравнительной физиологии домашних животных (1933).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GENETICS

INHERITANCE OF BIOCHEMICAL CHARACTERS IN ANIMALS IN CONNECTION WITH GROWTH

By V. I. PATRUSHEV

IV. DIFFERENCES IN COMPOSITION OF BLOOD IN HORSES, ASSES AND MULES

(Communicated by N. I. Vavilov, Member of the Academy, 16. III. 1938)

The present paper is a part of a series of investigations undertaken by the Institute of Genetics of the Academy of Sciences of the USSR to find out connections between blood composition and productivity of animals.

It is well known that mules display heterosis with regard to endurance. Therefore it was of decided interest to investigate the relation between components of the blood and hybrid vigour.

Literature on varietal differences in blood composition, on change in individual components in connection with sex and age, feeding, wearing is rather abundant; it demonstrates the possibility of making use of blood indices for estimating constitutional types of animals (see list of literature) and of their productivity.

We have studied the volume of formed elements as compared with the volume of plasm, resistance of erythrocytes, specific gravity and dry residue of blood, total and reduced glutathione content, activity of catalase. A set of indices was thus chosen which should give a rather complete idea of the condition of red blood and of its biochemical components which may to a certain extent picture the redox processes occurring in tissues. It should be noted that a very important rôle is being recently ascribed by biochemists to redox processes in hydrolysis and synthesis of proteins and, consequently, in processes of organic growth.

Studies were conducted at the horse-breeding farm № 68 (Uzbekistan) in November 1937. Altogether 200 horses, asses and mules have been investigated.

Animals were at pastures and fed by groups with concentrates.

The greatest group of horses was represented by mule dams of heavy weight and of half-breed origine. Asses belonged to a rather tall Bukharian variety. Mules considerably exceeded in size the asses at any age and approximated in height (mensured to the withers) the mares and mule dams.

It was typical that male asses and mules lagged behind in growth as compared with females up to $3^1/_2$—4 years of age. Further on males exceeded females in size.

Sexual Dimorphism and Age Differences in Blood Composition. All the blood indices which were studied by us showed age variation; at the beginning they increase somewhat and

then decrease. Thus, for instance, the volume of formed elements of blood increases from 39% in six months old female mules to 42% in one year and a half old animals, further on decreasing gradually to 31.6% in four and a half years old females.

Up to one year and a half the specific gravity and the dry residue of the blood are similarly increased in female mules and female asses. An increase in concentration of reduced and total glutathione is noted in adult mares as compared with the youngs, as well as in female mules up to the age of one year and a half.

Quite different is the age variation of the composition of blood in asses showing continuous growth of all indices up to the adult age. Curves of age variation of formed elements in male and female asses may serve as example; they are more or less typical of the rest of blood components (Fig. 1). Hormo-

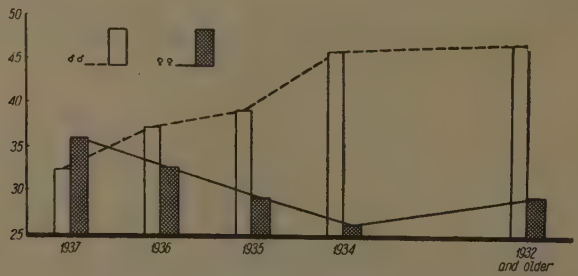


Fig. 1. Age and sexual differences in the volume of the formed elements of the blood in ass.

nal activity of testes may account for such differences between males and females. This assumption is based by us on the lack of increase in blood indices in emasculated mules.

No less interesting is the fact of a strong drop of blood indices in asses and mules after the age of one year and a half, as compared with horses, especially if one takes into consideration that the asses investigated attained to this time 97% of the height (measured to the withers) of adult animals, while horses continued intensely growing.

Lagging behind of the young males in growth as compared with females was noted above. A similar phenomenon is observed in blood indices. The volume of formed elements of the blood in one year and a half old mares is 41%, and in young stallions 35% only. Analogous data are available for asses and mules not only for the volume of formed elements, but also for specific gravity, dry residue of the blood, glutathione content, catalase activity and resistance of erythrocytes. In older animals males exceed females in all the indices enumerated above.

From our point of view this parallelism of lagging behind of males in growth and lowered blood indices is a good illustration of the connection between differences in growth and those in the composition of the blood. This is the more probable that the preponderance of males over females in blood composition is established after the age of one and a half—two and a half years, that is considerably earlier than the preponderance in size is established. The increased rate of blood production in males ensures (aside from other causes) a more intense metabolism and growth in further stages of development.

Specific Differences in Blood Composition. Volume of Formed Elements and Plasm. Determination of the volume of formed elements and plasm was made by means of

precipitation of oxalated blood in measuring test tubes after Sahli. The results of investigations are shown in the graph and curves (Fig. 2). Mules occupy the first place as to the volume of formed elements up to the age of one year and a half. Owing to a more pronounced drop of blood indices in asses and mules with the age, mares assume the first place after the age of one year and a half (when females are compared). The volume of formed elements of the blood in mules is an intermediate one.

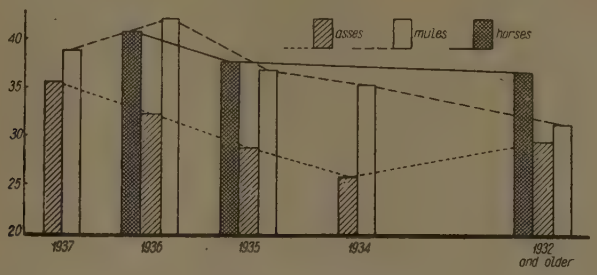


Fig. 2. Differences in the volume of the formed elements of the blood in horse, ass and mule.

Specific differences in dry residue of the blood and in specific gravity show the same tendency as in the volume of formed elements. We will therefore not dwell upon them.

Resistance of Erythrocytes. The erythrocytes of six months old female mules become haemolyzed and precipitate in highest concentrations of salt solutions as compared with the erythrocytes of female asses and young mares (in other words, they appear to be more resistant). Further on, age variations occur which are typical of other blood indices; the latter result in a smoothening of differences in the resistance of erythrocytes. Differences in resistance of erythrocytes in asses and horses are insignificant.

Reduced and Total Glutathione Content. It may be seen from Table 1 that young asses of both sexes possess a higher glutathione concentration as compared with horses.

One year and a half old mules insignificantly exceed asses in glutathione content, while in older age these differences are lacking. As to females, the glutathione content may be considered equal in female mules and female asses.

Activity of Catalase. In all the age and sex groups investigated the first place as to the catalase activity of the blood is assumed by horses, the second by mules, and the last one by asses. Owing to the fact that the specific differences in this character are highly significant (Table 2), we do not present numerical data in order to save space.

To elucidate the significance of differences in certain indices Table 2 is added.

It should be noted in concluding that the comparison of the blood indices investigated gives higher indices in horses of heavier type (mule dams) than in speed animals (the half-breed of the English race-horse and Achaltekinets); investigation has been conducted on a limited scale.

We were led to the following conclusions:

1) Young males of asses, horses and mules lag behind the females in growth (asses up to 2—3 years; mules, to 3—4 years) and possess to one and a half—two and a half years of age lower indices of blood composition as com-

Table 1

Glutathione Content of Blood in Horses, Asses and Mules

Specific and sex groups / Age groups	Indices	Young mares		Young stallions		Male asses		Female asses		Male mules		Female mules	
		Red.	Total	Red.	Total	Red.	Total	Red.	Total	Red.	Total	Red.	Total
6 months	*n*	—	—	—	—	—	—	—	—	—	—	6	6
	M	—	—	—	—	—	—	—	—	—	—	32.5	37.9
	±*m*	—	—	—	—	—	—	—	—	—	—	± 3.2	± 3.5
1 ½ year	*n*	7	—	9	—	5	5	4	4	5	5	—	—
	M	28.5	—	24.1	—	43.6	48.0	45.4	49.6	48.4	53.0	—	—
	±*m*	± 2.0	—	± 0.8	—	± 3.0	± 5.0	± 2.3	± 3.6	± 3.0	± 3.6	—	—
2 ½ years	*n*	4	2	—	—	7	7	6	—	3	3	5	5
	M	32.6	38.7	—	—	47.5	55.7	36.4	—	44.7	48.6	36.1	40.1
	±*m*	± 2.1	± 1.0	—	—	± 5.0	± 6.0	± 1.2	—	± 4.5	± 4.5	± 2.5	± 1.9
3 ½ years	*n*	—	—	—	—	4	4	3	—	8	8	5	5
	M	—	—	—	—	42.6	57.2	33.7	—	41.2	43.3	32.2	37.6
	±*m*	—	—	—	—	± 8.6	±10.9	± 1.2	—	± 3.1	± 3.8	± 2.1	± 2.3
Adult mares	*n*	24	24	—	—	6	—	5	—	—	—	—	—
	M	29.0	33.8	—	—	59.0	—	30.9	—	—	—	—	—
	±*m*	± 1.3	± 1.3	—	—	± 2.6	—	± 0.8	—	—	—	—	—
Incl. mule dams	*n*	11	11	—	—	—	—	—	—	—	—	—	—
	M	24.9	28.2	—	—	—	—	—	—	—	—	—	—
	±*m*	± 0.8	± 0.9	—	—	—	—	—	—	—	—	—	—

Table 2

Probabilities of Differences of Blood Composition in Horses (H, H♀), Asses (A, A♀) and Mules (M, M♀)

Blood indices	6 months		1 1/2 year		2 1/2 years		3 1/2 years		Adults	
	Groups compared	P, %	Groups compared	P, %	Groups compared	P, %	Groups compared	P, %	Groups compared	P, %
Volume of formed elements	A>H	81.1	A>H	56.2	—	—	—	—	—	—
	—	—	H♀>A♀	99.3	H♀>A♀	92.6	—	—	H♀>A♀	100
	—	—	M>A	84.6	A>M	37.9	A>M	86.2	—	—
	M♀>A♀	81.1	M♀>A♀	99.7	M♀>A♀	99.7	M♀>A♀	97.1	—	—
	—	—	M>H	99.4	—	—	—	—	—	—
	—	—	M♀>H♀	78.8	H♀>M♀	15.5	—	—	—	—
Specific gravity of blood	—	—	H♀>A♀	87.7	—	—	—	—	—	—
	—	—	M>A	78.4	M>A	91.6	A>M	43.9	—	—
	M♀>A♀	55.8	M♀>A♀	91.6	M♀>A♀	96.5	M♀>A♀	84.6	—	—
	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—
Dry residue	A>H	37.3	H>A	100	—	—	—	—	—	—
	—	—	H♀>A♀	54.6	H♀>A♀	92.6	—	—	H♀>A♀	77
	—	—	M>A	100	A>M	37.3	A>M	77	—	—
	M♀>A♀	91.6	M♀>A♀	74.5	M♀>A♀	78	M♀>A♀	42.5	—	—
	—	—	M>H	100	—	—	—	—	—	—
	—	—	M♀>H♀	15.5	H♀>M♀	69.2	—	—	—	—
Glutathione	—	—	A>H	100	—	—	—	—	—	—
	—	—	A♀>H♀	100	A♀>H♀	84.6	—	—	A♀>H♀	77
	—	—	M>A	69.2	A>M	30.0	A>M	7.7	—	—
	—	—	—	—	A♀>M♀	7.7	A♀>M♀	42.5	—	—
	—	—	M>H	100	—	—	—	—	—	—
	—	—	—	—	M♀>H♀	64.9	—	—	—	—
Catalase	H>A	94	H>A	100	—	—	—	—	—	—
	—	—	H♀>A♀	100	H♀>A♀	100	—	—	H♀>A♀	100
	—	—	M>A	100	M>A	78	M>A	93.3	—	—
	M♀>A♀	99.8	M♀>A♀	100	M♀>A♀	100	M♀>A	98.5	—	—
	—	—	H>M	50.8	—	—	—	—	—	—
	—	—	H♀>M♀	100	H♀>M♀	100	—	—	—	—

pared with females (volume of formed elements, specific gravity, dry residue, reduced and total glutathione content of the blood).

2) Blood indices of asses and mules show a drop at one and a half—two and a half years of age as compared with those of horses. The character of curves of the blood composition in horses and asses is connected with their growth type.

3) Young asses exceed horses as to the total and reduced glutathione content of the blood and possess similar or insignificantly increased indices of the volume of formed elements (the males at the age from 6 months to one year and a half), of the specific gravity and of the dry residue of the blood.

The relations become changed with the age. Horses, beginning by the age of one year and a half, exceed asses in the volume of formed elements, in specific gravity and the dry residue of blood. In glutathione content differences between adult animals become immaterial. The activity of catalase is higher in the blood of horses.

4) The volume of formed elements, the dry residue of blood and the glutathione content in mules up to one year and a half of age is higher than in the two parental groups. Further on, all the blood indices in female mules

become intermediate, while in emasculated mules they drop below the indices of the two parental groups (formed elements, specific gravity).

Institute of Genetics.
Department of Animal Genetics.
Academy of Sciences of the USSR.

Received
19. III. 1938.

REFERENCES

[1] Г. С. Гамбаров и др., Тр. ВИЭВ, XII (1936). [2] В. И. Зайцев, Вестн. Казан. вет.-зоот. ин-та, № 1 (1931). [3] А. А. Кудрявцев, Тр. ГИЭВ, 562 (1928). [4] Е. С. Козлова и М. А. Семенов, Тр. ВИЭВ, XII (1926). [5] В. А. Косарев, Тр. ГИЭВ, II, вып. 1 (1924). [6] К. С. Косяков, Тр. по динамике разв., VII (1933). [7] Н. А. Никитин, Тр. Новочерк. вет.-зоот. ин-та, вып. 2 (1934). [8] Н. А. Никитин, Тр. Вологод. вет. ин-та, I (1936). [9] V. I. Patrushev, C. R. Acad. Sci. URSS, XIV, № 9 (1937). [10] Н. Преображенский и Н. Шпайер, Тр. Моск. зоот. вет. ин-та, II (1935). [11] В. А. Рациборский, Коневодство, № 10 (1937). [12] Д. М. Рикардо, Красная конница, № 10 (1937). [13] А. А. Розов, там же. [14] Синев, Клинико-лабораторное исследование крови и мочи домашних животных (1931).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GENETICS

INFLUENCE OF LIGHT UPON DEVELOPMENT OF POLLEN IN BARLEY

By G. S. ŽUKOVA

(Communicated by N. I. Vavilov, Member of the Academy, 14. III. 1938)

Physiological conditions of normal formation of pollen grains and emryosacks are far from being sufficiently investigated.

Comparatively large number of studies is devoted to the influence of temperature.

The majority of these studies ([1], [2], [3], [4]) had for object production of polyploid pollen under application of extreme conditions (mostly of low and high temperature) at the period of maturation divisions in pollen mother cells; they only demonstrated the influence of abnormal temperature condition on a certain stage of pollen development, i. e. reduction division. Temperature conditions which secure the normal course of pollen development from setting up of archaesporium to maturation of pollen remain as yet unknown.

Unsufficiently investigated is also the question on the rôle of light conditions in the development of pollen. It is a familiar fact that light, particularly day length, is an important factor of phenotypical determination of the sex of flowers [see survey by Correns ([5])]. It is indicated that insufficient light intensity causes pollen sterility in *Capsella* [Shull ([6])]. The work by Kraevoy and Kirichenko ([7]) contains an attempt to clear up the question from the standpoint of the theory of stage development. The authors arrived at the conclusion that the development of gametophytes depends upon special stage alterations in their cells. These alterations may occur when the duration of day light is from 6—24 hours. The conclusions arrived at by the authors are of preliminary character and are not supported by sufficient experimental data. We have been induced to the present study by the lack of clarity in the question of light conditions necessary for normal development of pollen, as well as numerous witnesses of physiologists ([8], [9], [10]) and plant breeders that under certain light conditions (insufficient number of long days given to plants at the outset in physiological experiments, poor illumination in hothouses during the winter, etc.) the cereals are growing sterile.

M a t e r i a l a n d M e t h o d. As a material we have taken two varieties of barley «Wiener» and «Zolotoy» which belong to long day varieties and clearly respond to the shortening of the day. The scheme of the experiments (1—9) is shown in Table 1:

It may be seen from the following scheme that the varying factor was the number of long days given to the plants of different groups at the beginning of cultivation. As controls served experiments № 1 and 9 (8-h. d. and 18-h. d.). Previous to planting, seeds were yarovized. The hothouse was heated, the

Table 1

	1	2	3	4	5	6	7	8	9
Number of long days given at the beginning .	0	5	10	15	20	25	30	35	Long day during whole period of experiment
Number of short 8 - hour days given after long days	Short day throughout the experiments								0
Conventional designation in following text . .	8-h. d.	5 l. d. + s. d.	10 l.d. + s. d.	15 l.d. + s. d.	20 l.d. + s. d.	25 l.d. + s. d.	30 l.d. + s. d.	35 l.d. + s. d.	18-h.d.

temperature being 25—28° C at day time and 10—15° C during night. By the end of April plants were transferred to the open and remained there until the end of experiments.

The long 18-hour day was attained in experiments by means of switching above the plants of 250 candle power lamps *.

Short 8-hour day was created by covering plants with boxes lined with dark lightproof paper for the period from 4 p. m. until 8 a. m. (16 hours).

To get an idea of the condition of the growing point of the plant before they are shifted from long day to short one, three plants out of each group were anatomized at corresponding intervals. The points of growth were examined under the binocular and drawn. Condition of pollen was examined for all experiments on aceto-carmin preparations. Besides, the most interesting material was fixed after Navashin. Permanent slides were subsequently prepared of that material.

Results of the Investigation. Difference in numbers of long days given to the plants in different experiments at the beginning of cultivation was in the first line reflected in moments of formation of ears and on the morphology and fertility of the ears.

Phenological observations are tabulated in Table 2.

It may be seen from the table that the two varieties of barley formed ears in all experiments, including 8-h.d. Formation of ears was attended by normal setting of grains in the 3 last experiments only. In the first 6 experiments the plants had sterile ears. A demarkation line between the first 6 classes and the last 3 ones was thus manifest. True enough, the sharpness of the transition is softened by the fact that in plants of the class 30 l. d.+s. d. we found single sterile ears and in plants of the class 25 l. d.+s. d. isolated fertile ears. In classes 8-h. d. and 5 l. d.+s. d. large amount of crippled underdeveloped ears was observed, apart from sterility. Examination of the points of growth of the plants previous to their shifting from the long day to the short one has shown that plants of the classes 5 l. d+s. d., 10 l. d.+ +s. d., 15 l. d.+s. d. and 20 l. d.+s. d. possessed very differently developed ears when transferred to the long day. Thus, plants of the class 5 l. d.+s. d. showed furcation on the growing cone, and plants of the class 20 l. d.+s. d. had a completely shaped spikelet and well expressed primordia of florets. Plants of the classes 10 l. d.+s. d. and 15 l. d.+s. d. assumed an intermediate position. Plants of the class 25 l. d.+s. d. strikingly differed from those of the foregoing classes. The differentiation of the flower is expressed here in formation of anthers and ovaries. Plants of the class 30 l. d+s. d. show a new

* One 250 candle power lamp illuminated 1 m² and was 50—60 cm above the plants.

Table 2

Results of Phenological Observations

Class	Sort	Appearance of seedlings	Ear formation	Time interval from sprouting to earing	Slowness as compared to 18-h.d.	State of the ear	Notes
8-h. d.	Wiener	11. VI	10. VIII	121	63	Sterile	Many crippled underdeveloped ears
	Zolotoy	»	13. VIII	123	64	»	
5 l. d.+s. d.	Wiener	»	5. VIII	116	58	»	
	Zolotoy	»	7. VIII	118	59	»	
10 l. d.+s. d.	Wiener	»	30. VII	110	52	»	
	Zolotoy	»	2. VIII	113	54	»	
15 l. d.+s. d.	Wiener	»	9. VII	89	31	»	
	Zolotoy	»	11. VII	91	32	»	
20 l. d.+s. d.	Wiener	»	25. VI	75	17	»	
	Zolotoy	»	27. VI	77	18	»	
25 l. d.+s. d.	Wiener	»	17. VI	67	9	»	Single fertile ears
	Zolotoy	»	17. VI	67	8	»	
30 l. d.+s. d.	Wiener	»	12. VI	62	4	Fertile	Single sterile ears
	Zolotoy	»	11. VI	61	2	»	
35 l. d.+s. d.	Wiener	»	8. VI	58	0	»	
	Zolotoy	»	9. VI	59	0	»	
18-h. d. . . .	Wiener	»	8. VI	58	0	»	
	Zolotoy	»	9. VI	59	0	»	

qualitative characteristic absent in all the foregoing classes. Young archaesporium is found on aceto-carmin preparations in young anthers of plants belonging to this class. Plants of the class 35 l. d.+s. d. possess completely developed archaesporium in their anthers.

A comparison of the data on sterility of ears (Table 2) with those on the condition of the point of growth of the plants belonging to the same classes, previous to shifting from the long day to the short one, leads to the following conclusion: the development of pollen and, further, the setting of grains takes place in barley in a normal way only when the archaesporial tissues are formed in anthers during the long day. As a matter of fact, plants of the first 6 classes were transferred to the short day having no internal differentiation of the tissues of the anthers and proved to be sterile, while plants of classes 30 l. d.+s. d. and 35 l. d.+s. d. were transferred to the short day with archaesporium already formed and proved to be fertile. Setting of archaesporium in the tissues of the anther should thus be considered as a moment, when sharp demarkation line in the development of plants sets in. If till this moment (including it too) the leading factor in the complex of conditions which ensure normal development of the plant is light, afterwards some other external factor assumes the leading rôle.

As already stated, we have conducted microscopical observation on the development of pollen. They had for purpose to find out what are the immediate causes of sterility of the plants grown under unfavourable light conditions.

Investigation of archaesporial tissue and of the reduction division in pollen mother cells showed no difference in sterile and fertile plants.

The most interesting data were obtained from the investigation of anthers, fixed prior to formation of ears in barley. While pollen of control plants possessed spherical shape, was filled up with contents and contained before dessemination normal vegetative nucleus and two sperms (Fig. 1), pollen of sterile plants was wrinkled, poor in contents and was composed of a mix-

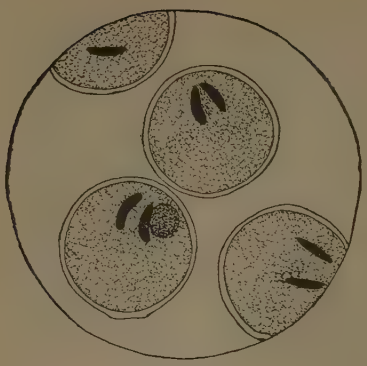


Fig. 1.

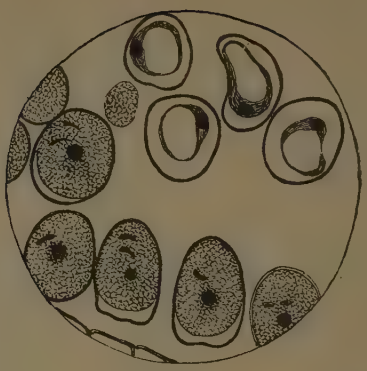


Fig. 2.

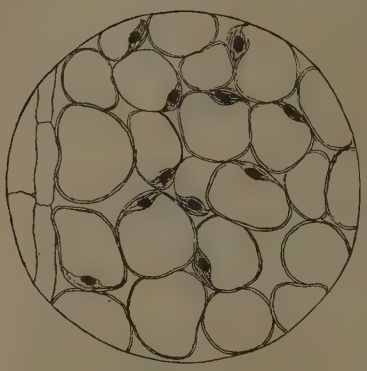


Fig. 3.

ture of one, two and three nucleate and even completely empty pollen grains (Fig. 2 and 3).

Investigation of the pollen lead us to conclusion that the immediate cause of sterility in barley under certain light conditions is the abnormal type of pollen structure which arises at late stages of pollen formation, namely, during transition from one nucleate to three nucleate condition.

Conclusions. The general conclusions which may be drawn from the data obtained are the following:

1) The essential condition for the normal development of pollen in barley is its cultivation under long day conditions up to the moment of formation of archaesporial tissue in the anthers of the flower.

2) Shortening of the duration of the long day and shifting of the plants to the short 8-hour day at the stage of ear formation prior to differentiation of archaesporium in the anthers leads to sterility of the plants.

3) The majority of disturbances of pollen development which lead to its sterility are confined to the period of transition from one nucleate condition to the three nucleate one, and consist in impoverishment in contents and arrest of the development at the one or two nucleate stage.

All-Union Institute of Plant-Breeding.
Department of Plant Physiology (Pushkin).

Received
17. III. 1938.

REFERENCES

[1] J. Belling, Jrnl. Gen., 15 (1925). [2] E. Borgestam, Arkiv för Botanik, 17, № 15, 1—27 (1922). [3] T. Sakamura and J. Stow, Jap. Jrnl. Bot., III, № 2 (1926). [4] F. Takagi, Sc. Rep. Tòhoku Imp. Univ. Sendai, Sc. Rep., 4th ser., III, № 3, Fasc. 2 (1928). [5] C. Correns, Berlin (1928). [6] G. Schull, Mem. Hort. Soc. New York, 3 (1927). [7] S. Kraevoy a. Kirichenko, C. R. Acad. Sci.URSS, № 6, 171—175 (1935). [8] В. И. Разумов, Соц. растениевод., № 15 (1935). [9] В. И. Разумов и М. И. Смирнова, Проблемы сев. растениеводства, IV (1934). [10] В. И. Разумов и М. И. Смирнова, (Тр. прикл. бот., сер. 15, № 5 (1936).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

GENETICS

CONTRIBUTORY EFFECT OF HEAT WITH IRRADIATION IN THE PRODUCTION OF MUTATIONS

By N. N. MEDVEDEV

(Communicated by N. I. Vavilov, Member of the Academy, 15. II. 1938)

Problem

It has been shown by the writer in the preceding communication (1) that X-raying of *Drosophila melanogaster* males at the low temperature (0°C) considerably increases the frequency of mutations produced as compared with that when X-ray treatment is made at room temperature (ca. 18—20°C).

In connection with this finding it seemed of interest to make clear the question whether the high temperature influences the mutation frequency when applied also for a short time during which the flies are subjected to X-ray treatment.

With this purpose in mind the writer has carried out a series of experiments and studied the frequency of lethal mutations arising in the progeny of *D. melanogaster* males X-rayed at high (ca. 36—39°C) and at room temperature (19—20° C) respectively.

Material and Method

The material and method used in experiments under consideration with the exception of temperature treatment and of some decreasing of the X-ray dosage were quite similar to those used in the first series of experiments dealing whith simultaneous influence on the mutation frequency of X-rays and low temperature. As in the previous experiments the attention was paid to standardization of environment and of age of males to be treated, which possessed the same *X*-chromosome with *y* and *fa* genes.

Before each X-raying the males of the same age yielded from several bottles were mixed together and then divided at random into two equal parts; one of these was to be X-rayed at room temperature (19—20° C) and the second one at high temperature (ca. 36—39°C).

The X-raying was always carried on under the following conditions: 105 kV; 5 mA; 1 mm aluminium filter; 20 cm distance from target. The dosage in *r* units is shown in the table.

The ClB-method of detecting lethal mutations in the *X*-chromosome of treated males was used throughout the experiments. All the doubtful in F_2 lethals and semi-lethals were checked in the third generation.

Summarized Data of Experiments on the Influence of High Temperature During X-Ray Treatment

№ of experiments	Dosage in r units	Treatment in min.	♂♂	X-ray treatment at room $t°$ (19—20° C)					X-ray treatment at high $t°$ (ca. 36—39° C)					Diff $\pm \epsilon_{diff}$	Diff. / ϵ_{diff}
				№ of X-chromosomes studied	Mutations found: lethals	semi-lethals	total	%	№ of X-chromosomes studied	Mutations found: lethals	semi-lethals	total	%		
I	4.000	34.5	*w^a f*	370	32	1	33	8.92	645	38	2	40	6.20	0.0272 ± 0.0168	1.62
II	4.000	34.5	»	317	24	3	27	8.51	273	11	9	20	7.32	0.0119 ± 0.0223	0.53
III	4.000	34.1	*yfa*	456	56	11	67	14.70	386	34	5	39	10.10	0.0460 ± 0.0229	2.01
IV	4.000	34.1	»	360	46	7	53	14.72	500	42	8	50	10.00	0.0472 ± 0.0224	2.11
V	4.000	31.4	»	230	10	1	11	4.78	230	5	—	5	2.17	0.0261 ± 0.0171	1.53
VI	4,000	33.0	»	400	43	1	44	11.00	445	35	2	37	8.31	0.0371 ± 0.0202	1.83
VII	4.000	33.0	»	430	32	8	40	9.30	450	27	8	35	7.77	0.0153 ± 0.0188	0.81
VIII	4.000	32.0	»	460	32	2	34	7.39	460	32	5	37	8.04	0.0065 ± 0.0176	—0.37
IX	4.000	23.0	»	337	29	3	32	9.50	340	22	2	24	7.06	0.0244 ± 0.0212	1.15

$$\frac{\sum_{diff}}{\sqrt{9}} = 3.74$$

Results Obtained and Conclusions

Summarized data of experiments are given in the table. As a comparison of the two series shows, there is definite influence of the high temperature on the mutation frequency when temperature treatment is applied during X-raying. But in contradistinction to cold the influence of the high temperature causes the amount of mutations arisen to decrease compared with the control series of experiments.

The data of the table also show that the differences between the control and heat series considerably vary from experiment to experiment, but except the eighth experiment have always the same trend. The combine results indicate that the difference between two series in question is 3.74 times as high as its standard error, i. e., it is statistically highly significant.

The results of further series of experiments, which show that the differences observed are due to different temperature treatment, as well as the description of method used for heating and cooling the flies during X-raying will be published elsewhere.

Institute of Genetics.
Academy of Sciences of the USSR.
Moscow.

Received
26. II. 1938.

REFERENCES

[1] N. N. Medvedev, C. R. Acad. Sci. USSR, IV, № 6—7, 283—285 (1935).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

PLANT PHYSIOLOGY

THE RÔLE OF GROWTH HORMONES IN FORM-BUILDING PROCESSES. III. EFFECT OF HETEROAUXIN TREATMENT OF SEEDS UPON GROWTH AND DEVELOPMENT OF PLANTS

By M. CH. ČAJLACHJAN and L. P. ŽDANOVA

(Communicated by A. A. Richter, Member of the Academy, 3. III. 1938)

In two previous papers ([3],[4]) the authors have shown that the changes in growth hormones observed on photoperiodism and yarovization lack of any connection with the acceleration of plant's development and produce no effect on budding and flowering.

The use of synthetic preparations of growth hormones—auxins, in order to make out their influence upon the formation of blossoms, was the next step of authors' research. Some of the investigators inducing root formation in adult plants rubbed the stems with a paste containing heteroauxin, but not a single case was reported when such treatment had accelerated the budding or flowering of plants.

Aside from rubbing with paste, there was applied an immersion of cuts of plants in aqueous solutions of auxin and heteroauxin. In his experiments on hormonization of seeds Cholodnyj ([1], [2]) immersed the seeds of oats and other plants in aqueous solutions of heteroauxin previous to their planting in soil. In other experiments he kept oat seeds in crumbed maize endosperm freed from embryos. In this latter case the test plants of oats flowered 12 days earlier than the controls. The treatment with heteroauxin produced no acceleration of flowering, yet the oats from the seeds treated with heteroauxin were quickened in growth and their seed crop was higher than in controls. From these experiments Cholodnyj concluded that an increase of auxin concentration in seeds and embryos at the first stages of sprouting, probably, accelerated the whole subsequent development of plants.

Quite contradictory was the opinion advanced by Roodenburg ([6]) who believes, starting from theoretical reasons, that just the impoverishment of plants in growth hormones leads to accelerated flowering and ripening.

The authors' experiments carried on in summer of 1937 aimed at establishing the effect of heteroauxin introduced into the seeds artificially upon the growth and development of plants. The following plants were sown for experiment: summer wheat *Lutescens* 062, winter wheat *Lutescens* 0329, oat 776 of Shatilovskaya test station, millet, summer vetch, hemp, white mustard, perilla, flax and peas. Previous to planting, the dry seeds were kept for 24 hours in aqueous solutions of heteroauxin or β-indolyl acetic acid; the latter was received ready made from Dr. Manske, Canada. The concentrations of the solution were 10, 25 and 50 mg of preparation per 100 cm^3 of distilled

water. The control seeds were immersed in distilled water. After 24 hours the seeds were taken out of the solution and without washing planted in the soil in earthen pots. Planting was done on June 10, 1937. For flax and peas there was one concentration more, viz. 5 mg per 100 cm^3, these seeds being planted on July 28, 1937. The experiment was carried on in three sets.

Later on phenological observations were made and the height of plants was measured every ten days.

High concentrations of heteroauxin stopped sprouting in all plants. Part of them, as summer and winter wheat, hemp, perilla, were affected only by the highest concentration, whereas in others, as mustard, flax and peas, the stopping effect gradually increased with concentration. At the subsequent stages of development (budding, earing, flowering, ripening) the plants from seeds treated with heteroauxin lagged somewhat behind as compared to controls. This lagging, however, had no other reasons than the plants being stopped at sprouting, and was markedly expressed only in the case of mustard. The length of the period from the appearance of seedlings till the outset of ripening of mustard was: in controls, 33 days; in experiments treated with 10 mg heteroauxin per 100 cm^3 of water, 32 days; with 25 mg per 100 cm^3, 38 days, and with 50 mg per 100 cm^3, 36 days.

Not a single case of accelerated ripening could be observed. Both the controls and experimentals of perilla gave no flowers nor buds, while the plants of winter wheat formed no stalk.

Heteroauxin exerted its influence not only on the rate of germination, but also upon the subsequent growth of plants. The response of the plants to influence of heteroauxin was by far not similar in different species. This is evident for oats, summer wheat, flax and mustard by the data of the table, where the height of plants measured every ten days is given.

Height of Plants (in cm) as Influenced by the Treatment of Seeds with Heteroauxin

Plants	Date of planting	Number of plants	Heteroauxin concentration in mg per 100 cm^3 of water	Dates of measurements				
				20.VI	1.VII	11.VII	20.VII	31.VII
Oat 0776 of Shatilovskaya station	10.VI	13	Control	11	31	36	58	67
		15	10	11	32	38	60	73
		15	25	12	35	41	57	77
		15	50	12	32	42	53	69
Flax	28.VII*	21	Control	12	23	40	64	92
		22	5	10	19	34	54	80
		24	10	10	19	34	53	78
		10	25	4	11	22	36	51
		1	50	1	5	9	18	20
Summer wheat *Lutescens* 062	10.VI	15	Control	17	34	49	72	86
		15	10	17	35	50	71	81
		15	25	14	32	48	69	80
		15	50	12	32	50	73	85
White mustard	10.VI	9	Control	—	15	38	45	47
		9	10	—	15	41	60	64
		9	25	—	11	33	58	66
		8	50	—	8	24	52	69

* Measured on Aug. 15, Aug. 25, Sept. 5, Sept. 15, Sept. 25.

The table shows the heteroauxin to produce an insignificant acceleration of growth in oat plants.

Fig. 1. Mustard plants from seeds treated with heteroauxin solutions, 25 days after planting. *1*—control, *2*—10 mg concentration, *3*—25 mg concentration, *4*—50 mg concentration (photo taken on July 5, 1937).

In flax the heteroauxin stops the growth from the beginning till the end of the vegetation, the lagging of growth being the greater the higher the concentration of heteroauxin. The same was observed in the case of vetch.

A great group was composed by plants whose behaviour approached to that of the summer wheat. Therein belong winter wheat, millet, peas, perilla

Fig. 2. The same plants of mustard 53 days after planting (photo taken on August 2, 1937).

and hemp. The heteroauxin stopped the growth of these plants during the first 10—15 days; later on the difference vanished and the experimentals attained the height of the controls.

Peculiar was the response of the mustard to the action of heteroauxin. From the outset its growth was stopped as in other plants: the plants were the smaller the higher the concentration of heteroauxin (Fig. 1). As seen from the photograph taken on July 5, the average size of the controls (*1*) was 26 cm, that of the experimentals being 24 cm—weak concentration (*2*), 18 cm—middle

concentration (*3*) and 12 cm—strong concentration (*4*). In the course of further growth the experimentals exceeded the controls in height so that at the time of the second photograph (Fig. 2) the relation was opposite: the controls had an average size of 47 cm; the experimentals, 64, 66 and 69 cm respectively.

It appeared thus that the processes of growth in mustard are protracted by the effect of heteroauxin, and the test plants grow higher than the controls. The drawing out in time of growth processes is accompanied by a consumption of plastic substances and this seems to account for the delayed ripening of seeds observed in mustard. Very likely, the delay of shoot flowering under the influence of heteroauxin reported by Dostal and Hoŝek [5] in *Circaea intermedia* is also connected with the intensifying of growth processes.

We may conclude thus that the artificial introduction of a synthetic preparation of growth hormone—heteroauxin—into the plant calls forth a modification of growth processes without immediately affecting the formation of buds and flowers.

The previous works of the authors [3,4] have proved that the changes in the concentration of growth hormones taking place on the photoperiodism and yarovization of plants are not connected with the rates of development, formation of buds and flowers. The same is observed with respect to growth hormones introduced from without.

This leads us to a general conclusion, viz. that the growth hormones play no decisive part in plants passing from the vegetative growth to reproductive development.

Timiriazev Institute of Plant Physiology.
Academy of Sciences.

Received
4. III. 1938.

REFERENCES

[1] N. G. Cholodnyj, C. R. Acad. Sci. URSS, III, № 9, 439—442 (1936). [2] Н. Г. Холодный, Природа, № 2, 36—47 (1937). [3] M. Ch. Čajlachjan a. L. P. Ždanova, C. R. Acad. Sci. URRS, XIX, № 1—2 (1938). [4] M. Ch. Čajlachjan a. L. P. Ždanova, ibid., XIX, № 3 (1938). [5] R. Dostàl und M. Hošek, Flora, 31, № 3, 263—286 (1937). [6] J. W. M. Roodenburg. Ber. d. D. bot. Ges., 55, H. 1, 5—32 (1937).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

PLANT PHYSIOLOGY

QUALITATIVE CHANGES OF RUBBER AND RESINS IN KOK-SAGHYZ ROOTS IN THE COURSE OF THE PLANT DEVELOPMENT

By S. M. MASHTAKOV

(Communicated by A. A. Richter, Member of the Academy, 14. III. 1938)

The question of qualitative state of rubber and resins in the soviet root-rubber plants in connection with their development as well as with other factors is a new one and has never been discussed in special works. The experimental data reported on qualitative changes of rubber content in tropical rubber plants ([1], [2], [3]) are so scanty and conflicting that no definite conclusions can be drawn from them. Thus, until quite recently there was no clear idea whether it is possible and to what extent to alter the qualitative indices of rubber (at least, the degree of its polymerization) in plants during their development.

The quality of kok-saghyz rubber was analyzed by means of determination of its molecular weight at different stages of plant development according to Staudinger ([4]). This was done after the method of measuring relative viscosity of benzene solutions of rubber by means of Wo. Ostwald's viscosimeter for volatile liquids, in a water thermostat at the temperature 25° C (±0.1°) and in weak orange light.

The cold extraction of rubber from plant material, washed previously in water (for removal of water soluble substances) and in acetone (for removal

Table 1

Concentration (C) of rubber solution		4.VII		3.VIII		3.IX		4.X		25.X		15.XI	
		Viscosity		Viscosity		Viscosity		Viscosity		Viscosity		Viscosity	
C, %	C, mol	η_r	η_{sp}	η_r	η_{sp}	η_r	η_{sp}	η_r	η_{sp}	η_r	η_{sp}	η_r	η_{sp}
0.5	0.0735	—	—	6.98	5.98	9.07	8.07	11.54	10.54	13.91	12.91	14.55	13.55
0.25	0.0367	2.12	1.12	3.15	2.15	3.58	2.58	4.09	3.09	4.76	3.76	4.91	3.91
0,125	0.0187	—	—	1.84	0.84	1.97	0.97	2.14	1.14	2.31	1.31	2.50	1.50
0.05	0.00735	1.16	0.16	1.24	0.24	1.34	0.34	1.36	0,36	1.45	0.45	1.59	0.56
0.025	0.00367	1.07	1.07	1.12	0.12	1.15	0.15	1,19	0.19	1.21	0.21	1.28	0.28

of resins) was performed in nitrogen medium in darkness for 3 days. Benzene extract was filtered through a layer of glass wool.

The quantity of hydrocarbons contained in rubber was determined in the filtrate, after which the viscosity of benzene solution of different concentrations was measured.

The experiments were conducted with kok-saghyz plants planted on April 28, 1937, at the first year of vegetation. Root samples were taken on July 4, August 3, September 3, October 4, October 25 and November 15.

The results of rubber viscosity determinations are summed up in Table 1.

The relation between the viscosity of diluted solutions and the length of rubber molecules is after Staudinger expressed by the formula: $\frac{\eta_{sp}}{C} = K_m \cdot M$, where η_{sp} is specific viscosity $(\eta_r - 1)$, C — concentration of solution, expressed in mol, K_m — a constant equal for the given polymerohomologous series to $3 \cdot 10^{-4}$.

The molecular weigth M calculated after this formula, from viscosity measurements obtained with the concentration of solution 0.025% (C mol 0.00367), and the degree of rubber polymerization undergo changes which may be roughly expressed as follows (Table 2).

Table 2

Dates	1.VII	3.VIII	3.IX	4.X	25.X	15.XI
Molecular weight	60 000	100 000	136 000	170 000	190 000	250 000
Degree of polymerization .	900	1 400	2 000	2 500	2 800	3 600

The data of these experiments suggest that rubber in kok-saghyz roots at the beginning of its formation is in the state of low polymerization. The degree of polymerization and the molecular weight of rubber rise with plant development. Polymerization of rubber in the roots proceeds also during the period when the plants pass to the state of rest (end of October—middle of November).

Quantitative determinations showed that the ratio of rubber increases parallel to the polymerization process. As the molecular weight of rubber determines its industrial characteristics, one may come to the general conclusion that both the increment of quantity and certain improvement in quality of rubber take place in the course of root development.

In connection with this it appears necessary to seriously reconsider as to the terms of harvesting of kok-saghyz roots. In order to preserve the quantity and quality of rubber it should be suggested to harvest kok-saghyz crops not in autumn (September, beginning October, as it is practiced at present). of the first, but in the spring of the second year of vegetation. The expediency of this suggestion should be confirmed further on by special investigations.

The quality of resins was determined by measuring physical and chemical constants widely applied in fat analysis (5), which included: acid number, ether number, saponification number, iodine number and the index of refraction.

The extraction of resins from the roots was performed by means of acetone at the temperature 20—25° C for 3 days. For determination of constants the acetone extract was first evaporated in a vapour-bath and then dried at the temperature 80—85°C.

The determination of the resin ratio to the dry weight of roots showed that it changes but slightly during the vegetation period. The content ratio of

Table 3

Dates	4.VII	3.VIII	3.IX	4.X	25.X	15.XI
Rubber in %	1.8	4.4	5.0	5.7	7.4	7.8
Resins in %	3.9	2.6	2.2	2.4	1.8	2.4

rubber to resins changes favourably, from the industrial point of view, with the development of roots (Table 3).

The figures of Table 3 indicate that during the vegetation period there is observed in resins an accumulation of organic acids in free and bound state (acid and ether numbers) in consequence of which the quantity of saponifiable ingredients (saponification number) increases too. The index of refraction of resins decreases gradually with the increase of the age of plants. The quantity of unsaturated compounds (iodine number) remains without appreciable change during the whole period of vegetation.

The qualitative characters of resins changed as follows:

Table 4

Dates	4.VII	3.VIII	3.IX	4.X	25.X	15.XI
Acid number	34.16	44.95	54.10	54.99	51.10	100.43
Ether number	62.02	59.04	70.65	87.81	98.25	100.20
Saponification number	96.18	103.99	124.75	142.80	149.35	200.63
Iodine number	—	99.71	97.12	105.54	96.78	111.36
Index of refraction	1.5167	1.5142	1.5084	1.5048	1.5035	1.4920

The storing of organic acids should be favourable for the practice because in the presence of various accelerators organic acids, according to literary data ([6], [7], [8]), play an essential part in the process of vulcanization, hastening the latter and improving the quality of the product.

Thus, throughout the course of kok-saghyz development till the very end of vegetation period, including the state of rest, there is observed a gradual increase of quantitative and qualitative indices of rubber-resin complex.

Institute of Rubber
and Gutta-Percha.

Received
17. III. 1938.

REFERENCES

[1] C. Weber, Ber. d. D. chem. Ges., **36**, 3108 (1903). [2] Harries, ibid., **37**, 3842 (1904). [3] Hinrichsen u. Kindscher, ibid., **42**, 4329 (1909). [4] Штаудингер, Высокомолекулярные органич. соединения, пер. (1935). [5] Демьянов и Прянишников, Жиры и воска, изд. 3 (1932). [6] Готлоб, Технология каучука, пер. (1933). [7] Whitby a. Greenberg, Ind. a. Engin. Chem., **18**, 11 (1926). [8] Van-Rossem a. Dekker, ibid., **18**, 11 (1926).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

PLANT PHYSIOLOGY

RUBBER ACCUMULATION IN KOK-SAGHYZ AS A FUNCTION OF ITS BIOLOGICAL MATURING PROCESS

By A. A. NICHIPOROVICH and V. N. BOUROVAYA

(Communicated by A. A. Richter, Member of the Academy, 15. III. 1938)

From numerous observations of the process of rubber accumulation in our rubber plants it may be seen that its relative content computed for total dry plant mass increases with the age of plants. This circumstance alone suggests that with the age the general trend of biochemical processes is changing in plant which is followed by an intensified rubber production.

The experimental material available proves, however, that the most sharp differences in the rubber content of kok-saghyz roots are due to factors affecting most powerfully the process of kok-saghyz biological maturation, expressed, for instance, in the rapid coming of the period of rest.

At the same time our principal rubber plant, kok-saghyz, is a plant extremely liable to change the rate of its biological maturing.

Changing the ratio of nitrogene to phosphorus in the nutrition ([1],[2]), as well as the humidity and temperature conditions, we may observe either a very early transition of kok-saghyz plants to the state of rest, or a continuation of active vegetation period up to the setting in of frosts. To solve the question whether it is possible to influence the course of rubber accumulation through the maturation process, it appeared above all essential to state, what general changes of organism accompany the plant development and to what extent the production of rubber is linked with these changes. For this purpose the samples of kok-saghyz plants were periodically investigated by V. N. Bourovaya, who took into account nutrition, conversion of various substances, rubber including, and their translocation. For short we quote a series of figures taken selectively and expressed in relative indices.

Table 1

Organs	Weight of dry mass in 100 plants at different dates in g				
	28.VI	20.VII	20.VIII	16.IX	16.X
Roots	1.5	15.2	52.6	108.2	170.8
Leaves	6.7	57.5	122.8	171.5	173.1
Total	8.2	72.7	175.4	279.7	343.9

Apparently the storing up of the general mass of kok-saghyz yield proceeds up to late autumn till the setting in of frosts. However, in September-October the mass of leaves hardly increases, while the root mass continues growing vigourously. In accordance with this the ratio of weight of leaves to that of roots varies sharply.

Table 2

Organs	Weight of dry mass of the organs in percentage to the weight of total mass at different dates				
	28.VI	20.VII	20.VIII	16.IX	16.X
Roots	18.8	20.9	30.0	38.7	49.7
Leaves	81.2	79.1	70.0	61.3	50.3

At the initial periods the most intensive is the growth of leaves, the growth of root mass being intensified later on. The data stated below suggest the gradual qualitative alterations in leaves with regard to their efficiency. The weight increment for a certain period and for 24 hours in average was determined from the difference between the weight of the plant mass at the beginning and at the end of the period (I). The average weight of dry mass of leaves for that period was determined as the mean between the two respective indices, i. e. between the weight at the beginning and at the end of the period (II).

The quotient of the first indices (I) divided by the respective second ones (II) gave the storage of total dry mass (in mg) computed for 1 g of leaf mass, assuming that the total increment of mass is essentially determined by the assimilating activity of leaves.

Table 3

Assimilating activity of leaves at different periods (increment in mg of total mass for 24 hours computed for 1 g of leaves)

28.VI—4.VII	4.VI—20.VII	20.VII—10.VIII	10.VIII—16.IX	16.IX—1.XI
209.82	110.7	53.7	21.4	12.9

Thus, the assimilating activity of leaves decreases continuously as the age of the plant increases.

Alongside of the changes of these correlations the general trend of biochemical processes of plants alters markedly which is illustrated by the data of Table 4. The figures of this table were obtained in the following way: the increment of the whole mass (in g) of 100 plants as well as the total amount of nutritive and reserve substances stored up in them (in mg) were recorded for the given period. Dividing the second indices by the first, one established to what extent the recorded substances participated in the storing of every new gramm of the total dry mass during the given period (mg per 1 g).

Prior to drawing any definite conclusion let us quote some figures characteristic of the course of changes in the ratio of the fundamental ingredients in the leaves and roots of kok-saghyz (Table 5).

Table 4

	Storing of substances in mg per 1 g of total mass increment at periods						
	Seedlings—10.VI	16.VI — 28.VI	28.VI — 4.VII	4.VII — 19.VII	19.VII — 10.VIII	10.VIII — 16.IX	16.IX — 16.X
Total nitrogen	55.3	44.7	39.1	33.2	28.1	21.4	29.9
Protein nitrogen	42.0	34.5	30.6	27.5	18.6	6.0	4.6
Total ash	157.9	165.0	142.1	141.8	105.9	73.7	55.3
Proteins (N prot. 6.25)	262.0	216.0	192.0	172.0	116.0	37.5	28.8
Inulin	32		116	115	174	298	459
Rubber	1.2		4.6	3.6	8.6	37.8	38.5

Table 5

Substances	Organs	Per cent of substances in dry mass of roots at different dates							
		28.VI	4.VII	20.VII	10.VIII	16.IX	1.X	16.X	1.XI
Total nitrogen	Leaves	4.9	4.7	4.1	3.4	2.9	2.7	2.2	2.6
	Roots	2.7	2.4	1.8	2.4	2.9	2.9	2.9	3.65
Protein nitrogen	Leaves	3.85	3.71	3.5	2.8	2.5	2.5	1.6	1.8
	Roots	1.7	1.51	0.9	0.9	0.8	1.0	0.9	1.0
The amount of dissolved sugars	Leaves	—	1.9	2.5	8.4	10.1	8.7	9.6	11.5
Inulin	Roots	18.8	38.6	50.8	53.5	52.8	46.2	50.7	46.5
Rubber	Roots	0.8	1.6	1.7	2.2	4.5	4.3	4.3	5.0
Resins	Roots	4.1	3.6	2.6	2.0	2.2	1.6	1.8	1.7

From the above data the following conclusions may be drawn:

1. The development of kok-saghyz similar to that of other plants ([3], [4], [5]) is accompanied by a successive well pronounced alteration in the regimen of nutrition and metabolism, reflecting the process of biological maturing of plants.

2. The first period is characterized by a relatively more intense growth of leaves, a high assimilating activity and a prevalent nitrogenous nutrition with well marked protein synthesis in leaves.

3. Owing to the intensive growth processes in leaves and intense protein synthesis in them, the storage of free carbohydrates is relatively insignificant.

4. As plants mature, the activity of the leaves with respect to protein synthesis slackens and the storing of free carbohydrates and non-albuminous forms of nitrogen compounds is taking place. At the same time carbohydrates and the products of protein disintegration begin to flow intensely to the roots. This causes the growth of the leaf bulk to slow while the growth of root-mass is strongly intensified. With that time sets in and becomes more and more intense and expressive the period of prevalent carbohydrate nutrition and the storing of carbohydrates in the roots.

5. Characteristic of kok-saghyz as a rubber plant is the fact that the period of intense accumulation of carbohydrates is accompanied by an increased formation and storing of the product we are interested in, viz. of rubber.

6. The comparatively stable content of resins and the slight change in the relative intensity of their production (in mg, per 1 g of total mass stored) throughout the periods of plant development prove that resins are very likely a by-product of general growth processes, and perhaps of the process of protein synthesis, since the ratio both of resins and of protein nitrogen in the roots remains almost unchanged throughout the vegetative period, except some tendency of slowing down after the complete formation of the rosette (4. VII). This statement agrees with that of G. V. Pigoulevsky ([6]), who believes that storing of resins in conifers is «a function of dry matter accumulation».

7. Rubber accumulation is, on the contrary, far more closely related with a decrease of protein production intensity and with intensified accumulation of free carbohydrates—features typical of the latest stages of kok-saghyz biological maturation.

8. Rubber storing being thus a function of the maturation process of kok-saghyz, the methods directly affecting it should be (as proved by practical experience) the most efficient if one aims at regulating the process and limits of rubber accumulation.

9. Owing to technical reasons the industrial digging of kok-saghyz is usually timed to end of September—beginning of October, when, as it may be observed from the respective data, the biological maturity of kok-saghyz is far from being completed and consequently the yields of rubber are considerably reduced.

10. Thus, following tasks are of great practical importance:

a) Stimulation of the biological process of maturation in such a way that it may be completed by the time of digging, which may be achieved, for instance, by applying the prevalent phosphorus-potassium nutrition in the second half of the vegetation period.

b) Breeding of some selected varieties distinguished by the most intensive development of roots and able at the same time to complete the process of biological maturation by the period of digging.

c) The discussion of the possibility to transfer the term of digging to the spring of the second year provided that the plants do not suffer any unfavourable qualitative changes throughout the period of wintering and vitality-rise in spring.

Institute of Rubber and Gutta-Percha.

Received 17. III. 1938.

REFERENCES

[1] А. А. Акулинина, Физиология и анатомия каучуконосов, сборник (1936). [2] А. А. Бельчикова, ibid. [3] И. Г. Дикусар, Свекловичное полеводство, № 6 (1936). [4] K. Mothes, Planta, 7, H. 2/3 (1929). [5] А. И. Смирнов, К характеристике возраста табачных листьев (1928). [6] Г. В. Пигулевский, Журн. Рус. физ.-хим. о-ва, LVI, вып. 5—9 (1925).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

ANIMAL PHYSIOLOGY

ON THE MECHANISM OF THE FORMATION OF CHEMICAL MEDIATORS OF NERVE IMPULSES

By CH. S. KOSHTOYANZ

(Communicated by I. I. Shmalhausen, Member of the Academy, 14. III. 1938)

The idea of the transmission of nerve impulses is more and more associated with that of the synthesis of some specific and highly active substances which were given the name of nervous mediators. After the classical works of Otto Levy and Dale it is assumed that stimulation of parasympathetic, as well as of somatic nerves, leads to the formation of highly active substances approaching (and according to some authors even analogous) to acetylcholine. This chemical substance, which had long ago been familiar to pharmacology, occupies quite an exceptional place in modern physiological investigations. At the present time its wide spread in nervous and other tissues of both vertebrates and invertebrates is firmly established. A series of authors have recently shown that surviving brain tissue of mammals is capable of synthesizing this substance (Quastel, Stademan). Analogous data have been obtained by the author of the present paper with regard to the nervous tissue of amphibian and mollusc. It becomes evident that in the cells of various tissues there occurs under the influence of nerve stimulation and perhaps also without the latter a synthesis of those specific substances called mediators of nerve impulses. Such syntheses seem to us to be of more general importance, since specific syntheses of peculiar chemical substances do naturally accompany not only nerve impulses, but also such forms of excitation as that of the egg cell during fertilization. My special investigations have shown the presence of an increase of the Wendt growth substances (auxin-like substances) in the eggs of amphibia.

However, the way this synthesis is brought about, its very mechanism, are far from being as yet sufficiently explicit. The present communication is devoted to the discussion of some experimental data and theoretical considerations pertaining to the problem of the mechanism of the synthesis of chemical mediators of nerve impulses.

The theoretical conjecture of our experimental search in this direction was based upon the idea that a special synthesis of peculiar chemical substances—mediators of nerve impulses—must be connected with those fundamental processes of synthesis and resynthesis which develop in the course of the general chemodynamics of a given cell, being a definite link of this process. We arrived at this natural conclusion partly after a long search for acethylcholine-like substances in protozoa, which have no nerve system. As may be seen from the experiments made in collaboration with R. Mitropolitanskaya,

infusoria extracts, as well as extracts of sponges, do not contain any acethylcholine-like substances. The same extracts, however, produce a considerable acethylcholine effect, after having been acetylized according to the usual method by acetic anhydride. It is obvious that this process involves acetylization of choline, contained in the above mentioned extracts.

It is known that high activity with regard to influence upon biological objects is peculiar not only to acetylcholine, but also to a series of choline ethers, e. g., pyruvate choline, and, probably, some others, which become hydrolized with choline esterase. In which way proceeds the synthesis of these choline ethers, whose participation in the transfer of nerve impulses is nowadays acknowledged by the majority of investigators, and how this synthesis is connected with the general chemodynamics of the cell, receptor of the impulse,—these are the questions which require analysis.

In the experimental analysis of the problem set before us we proceeded from the fact that substances capable of formation of choline ethers in particular, and those whose high physiological activity has been experimentally established (as, for instance, pyruvate choline, acethylcholine), are permanent components of cell metabolism, more particularly, of carbohydrate metabolism. In this connection pyroracemic acid should be mentioned, which is capable of producing pyruvate choline, as well as acetic aldehyde and acetic acid, necessary for the acetylization of choline. These substances are known as being intermediate products of complex cellular processes of carbohydrates transformation, as well as of transformation of fats. The simplest experimental evidence of this assumption would be secured, if the elimination of the formation of these substances was found to result in a partial or absolute failure of the synthesis of choline ethers, in particular of acethylcholine, the latter substance being connected with the realization of the influence of nerve impulses. In this case the normal course of the reaction of the transfer of nerve impulse from the nerve to the cell should be disturbed.

In the first series of our experiments, the results of which are reported in this preliminary note, we tried to affect carbohydrate metabolism by means of sodium fluoride. It is known that this substance produces the so-called fluoride block, which is to a considerable extent inhibiting the process of transformation of phospho-glyceric acid into pyroracemic acid. Using fluoride block, we break the normal course of metabolism detaining the process of formation of pyroracemic acid, as well as the processes of formation of acetaldehyde and acetic acid, which are connected with it and are known to occur both during the anoxydating and oxydating phase.

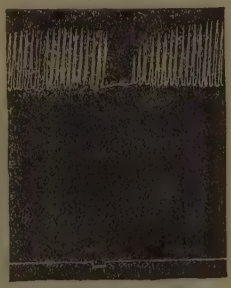
Changing the metabolic processes in the cell, we disturb the partial synthesis of choline ethers which participate in the complex process of realization of nerve impulse. Besides this total influence which is not differentiated according to the phases of fluoride action upon the initial step of the metabolism, fluoride was attracting our attention as a substance exerting an inhibitory effect on choline esterase, which is known to destroy acethylcholine and some other choline ethers.

The experiments were carried out on two kinds of material: a frog nervous-muscular prepation and on frog heart. In both cases the nervous tissue of the isolated organ (m. gastrocnemius, heart) were subjected (after the rate of the reaction had been established) to the action of $^1/_{50}$ Mol sodium fluoride solution, upon which the result of stimulation of the n. sciaticus and n. vagus for the m. gastrocnemius and the heart respectively were tested again. The duration of the effect of sodium fluoride upon the muscle ranges from 30—90 min. (preliminary); upon the heart—depending on the course of experiment, 5 to 30 min.

Results of the Experiments

Heart (experiments made together with R. L. Mitropolitanskaya). The heart was isolated together with the nerve stem of n. vagosympaticus. The rate of the heart response to the stimulation of the nerve with induction current from an induction coil of Dubois-Raymond was established under the conditions of the experiments with Staub's cannula. After this some sodium fluoride solution was introduced into the cannula and the nerve stimulation was repeated under the same conditions. Finally, some saline solution was introduced on the background of the sodium fluoride action, after which the nerve was stimulated again under the same conditions. The results of the experiments are given in Fig. 1.

As may be seen from the kymograms, the effect of sodium chloride has two phases. The first phase is characterized by a sharp increase of the action of n. vagus (acethylcholine action, see Fig. 1, *B*), and the second phase—by the elimination of this action, sometimes accompanied by a nervous effect of the action of the n. sympaticus only, involved in the stem stimulated (Fig. 1, *C*). The analysis of the experimental data may be as follows: during the first phase of its action sodium fluoride inhibits the hydrolytic effect of choline esterase upon acethylcholine, which results in the accumulation of this substance, and, consequently, in a prolonged stop of the heart. Adding new portions of saline solution, this superfluously accumulated acethylcholine is drawn away, and during the second phase of action sodium fluoride is inhibiting further synthesis of acethylcholine-like substances.



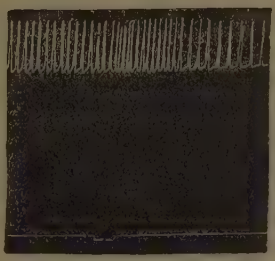


Fig. 1. Heart response to the stimulation of n. vagus: *A*—normal; *B* and *C*—after NaF treatment (see explanation in the text).

The latter phenomenon is obviously based on correlated processses of fluoride block of carbohydrate metabolism and of the inhibitory effect of choline esterase, which seems to be not only a hydrolizing, but also a synthesizing enzime. The fluoride block thus produces a block for the transfer of the impulse from the n. vagus to the heart. So far as the chemical nature of the mediation of this impulse by means of specific acethylcholine-like substances has been experimentally proved, it may be assumed that the synthesis of these substances is being prevented by the fluoride block of carbohydrate metabolism.

Skeletal muscle (experiments made together with A. M. Riabinovskaya). The experiments were carried out on an usual nervous-muscular

preparation of frog m. gastrocnemius. The stimulation of the sciatic nerve was produced by induction current. The maximum and the threshold of the muscle contraction when stimulated indirectly were previously determined. After the rate of the response had been established, the muscle was immersed for various periods (30 to 90 min.) into a vessel containing sodium fluoride solution, after which the threshold and the maximum were determined once more, the muscle being stimulated both indirectly and directly.

Part of the results of these experiments is shown in Fig. 2. As seen from kymograms of Fig. 2, after the muscle is kept in sodium chloride solution for an hour, indirect stimulation fails to produce any response (Fig. 2,*b*), while direct stimulation produces a distinct contraction (Fig. 2,*a*), although within a considerably smaller range than under normal conditions.

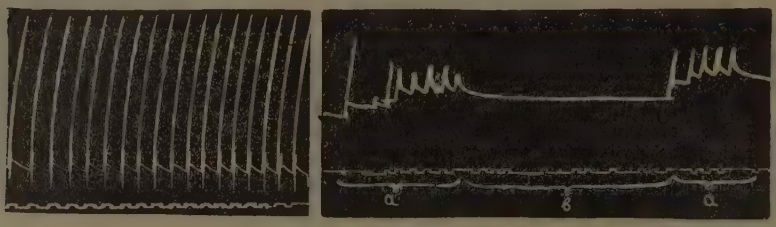


Fig. 2. Left—normal muscle; right—same muscle after one-hour long immersion in NaF; *a*—direct stimulation; *b*—indirect stimulation (see explanation in the text).

If we assume the point of view of Dale and his school, which have convincingly proved the fact of participation of acethylcholine-like chemical substances in the realization of the influence on the transmission of somatic impulse to the skeletal muscle, our results obtained by means of the fluoride block of carbohydrate metabolism should be considered as the consequence of a disturbance of the process of synthesis of chemical mediators of nerve impulse. As had been said above, this process should be considered in connection with the general process of metabolism.

Reporting these preliminary results, we do but set the problem, passing to its more detailed analysis, particularly with regard to a more precise localization of the synthesis in the common chain of metabolic processes. It seems most probable that in mammals the process is going on during the phase of oxydation, which is evidenced by the experiments of Quastel on the synthesis of acethylcholine by brain tissue. From the standpoint of comparative physiology of great interest is the problem of the course of these processes in those invertebrates, in whose chemodynamics a considerable part is played by anoxydative processes.

Department of Evolutional Physiology
of the Severzov Institute
of Evolutional Morphology.
Academy of Sciences of the USSR

Received
14. III. 1938.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

ZOOLOGY

ON THE DISTRIBUTION OF FORAMINIFERA IN THE KARA SEA

By Z. G. SČEDRINA

(Communicated by S. A. Zernov, Member of the Academy, 9. III. 1938)

This note is based upon the results of the treatment of the rich material collected by the Ice-Breaking Expeditions of the Artic Institute (1929—34) and by the High-Latitudes Expedition (on the ice-breaker «Sadko», 1935—36); these expeditions explored the Kara Sea, and partly, the Greenland Sea, the Barenz Sea and the Polar basin. The foraminiferal fauna of the Kara Sea, judging from the material analysed, consists of 102 species of much varied zoogeographical character. The nucleus is formed by cold water forms widely distributed in the Arctic. We have, without taking into account the new species and forms of no firmly established zoogeographic distribution, about 40% of these cold water forms. The rest is composed by boreal arctic forms, boreal, chiefly northatlantic forms, estuarian and cosmopolite forms and forms described from the abyssal of the Pacific and Atlantic Oceans. Such a complex zoogeographical composition of the foraminiferal fauna of the Kara Sea can be explained by the complexity and diversity of the hydrological regime in different sea regions, due to the presence of waters of different origin (local water, Kara water, Ob-Yenissei water, Atlantic water). As for the bottom relief and the specific hydrological regime, the Kara Sea can be divided into several regions; this is confirmed also by the peculiarities of the distribution of different groups of benthonic and planctonic animals ([1], [2], [3], [4]).

The table shows the distribution of the most characteristic and zoogeographically exactly determined species in different regions of the Kara Sea (Shokalsky strait and Vilkitzky strait excepted). These species can be subdivided into different complexes of forms, the principal of which are: 1) The complex of species characteristic for the shoals of cold seas, littoral zones and mouths of rivers. Some of these forms (*Ammobaculites cassis*) are able to withstand a considerable reduction of salinity of the basin (see table, № 1—10 inclusive). The new forms mentioned in the table have been described by the author in other works ([5]). 2) The complex of forms widespread in the Kara Sea, composed by cold water and arctic forms, and a relatively smaller number of cosmopolite species—*Reophax scorpiurus*, *Haplophragmoides canariensis* (see table № 17—24). 3) The third complex embraces boreal-arctic forms, boreal forms, widespread in the northern part of the Atlantic, forms from the abyssal of the Pacific and Atlantic Oceans (*Reophax guttifer*, *Cibicides wuellersdorfi*), species described for the Greenland Sea (*Cassidulina nocrossi*). Further on this complex is conventionally referred to as the «Atlantic» complex (see table № 25—42).

What is the distribution of these forms in the Kara Sea? Let us consider the general composition of the foraminiferal fauna within the limits of different sea-regions.

Region of the Western Taimyr—from Dickson Island to 85° E. Depths from 16 to 55 m. The foraminiferal fauna consists of single large sandy forms from the complex of widespread species, mainly of forms belonging to the first complex which contains, as already mentioned, cold and shallow water forms, forms of the continental shelf and brack water forms. The forms of this complex were not observed in the Kara Sea outside the limits of this region. Their presence seems to depend on general conditions of the habitat, such as shoaliness, low temperature of water and the possible influence of the discharge of the Ob-Yenissei waters and of their deposits.

South-Western Region — from Vaigach to Yamala. Depth 103—345 m. The nucleus of the fauna is formed by the complex of widely distributed large sandy forms with a mass development of *Rhabdammina abyssorum* in the deeper parts and of *Hyperammina subnodosa* in the offshore shallow zone near Yamala and in the Baidarazka Bay. It is of interest to note the occurrence of *Cornuspiroides striolatum*—a form widely distributed in the North Atlantic.

Novozemelskaya Cavity. Depth 140—365 m. The material collected in this region consisted of a small number of samples where the foraminiferal fauna was represented by large agglutinated forms from the complex of widespread species. There were also forms of the «Atlantic» complex: *C. striolatum*, *Nonion stelligerum*, *N. umbilicatulum*, *Cassidulina nocrossi*, which have, possibly, penetrated from the Barenz Sea or from the northern deep part of the Kara Sea with waters of Atlantic origin.

Northern Shoaliness. Region of the Central submarine ridge off Wiese-Ushakoff Island. Depth 27—74 m. The bulk of forms consists of species widespread in the Kara Sea, with a predominance of *Astrorhiza arenaria* and *Hormosina globulifera*. There are, besides, elements of the high arctic fauna and those of the «Atlantic» complex.

Voronin's Trough. Depth 180—297 m. The material was extremely scarce. As far as it shows, the foraminiferal fauna consists of widespread forms with elements of the «Atlantic» complex.

St. Anne's Trough. Depth 325—628 m. The fauna of this region—the richest and most varied of all—consists of two complexes. The nucleus is formed by the widespread forms and a great number of «Atlantic» forms. To judge from the material, all the forms of the «Atlantic» complex (№ 25—42) have been collected by the Sadko-expedition, 1935 ([5]), in the deep parts of the Greenland Sea, the majority north of Spitzbergen, in the Polar basin and in the St. Anne's trough. It appears that they enter the Kara Sea with Atlantic waters (from the North Atlantic through the Greenland Sea, and further rounding Spitzbergen from the north, through the Polar basin into the St. Anne's and Voronin's troughs). They can be regarded here as reliable indicators of waters of Atlantic origin.

Vilkitzky Strait. Depth 100—200 m. The nucleus is formed by the widespread in the Kara Sea large agglutinated forms, which are associated here by the peculiar *Astrorhiza* sp., apparently a new species, and elements of the «Atlantic» complex *C. striolatum*.

Shokalsky Strait. Depth 140—257 m. Alongside of the widespread species, there are found elements of the «Atlantic» complex (*C. striolatum*, *Cassidulina laevigata* and others).

A very interesting fact is the occurrence of great quantities of *Planispirina sphaera* d'Orb., widespread in the North Atlantic and recorded within

Species \ Regions	Region of the Western Taimyr	South-Western region	Novozemelskaya cavity	Northern shoaliness	Voronin's trough	St. Anne's trough
1. *Hippocrepina indivisa* Park.	×					
2. *Ammobaculites cassis* (Park.)	×					
3. » » n. var.	○					
4. *Verneuilina polystropha* Rss.	△					
5. *Spiroplectammina biformis* (Park. et Jon.)	△					
6. *Textularia* sp.	△					
7. *Miliolina* ex gr. *agglutinans* d'Orb	△					
8. *Elphidium gorbunowi* Z. Stschedrina	□					
9. *Trochammina* n. sp.	□					
10. *Reophax curtus* Cushm.	○					
11. *Rhabdammina cornuta* Br.	×	×				
12. *Trochammina turbinata* (Br.)	□	×				
13. *Nonion labradoricum* (Daws.)	○	△				
14. » *orbiculare* (Br.)	□			×		
15. *Elphidium arcticum* (Park. et Jon.)				×		
16. *Cornuspira foliacea* (Phill.)	×	△		△		
17. *Astrorhiza arenaria* Norm.	×	△	△	□		△
18. *Hormosina globulifera* Br.	×	×	△	□	□	□
19. *Haplophragmoides canariensis* (d'Orb.)	×	△	△	△	△	△
20. *Cibicides lobatulus* (Walk. et Jac.)	○	○	○	○	△	○
21. *Hyperramina subnodosa* Br.		○	△			
22. *Rhabdammina abyssorum* M. Sars		□	○	○		△
23. *Reophax scorpiurus* Montf.		△	○	○	△	×
24. *Saccorhiza ramosa* (Br.)		○	□	○		○
25. *Cornuspiroides striolatum* (Br.)		△	△	△	△	○
26. *Nonion stelligerum* (d'Orb.)			△	△	△	△
27. » *umbilicatulum* (Walk. et Jac.)			×	△		○
28. *Cassidulina nocrossi* Cushm.			×			△
29. *Astrorhiza limicola* Sandh.					△	○
30. *Globigerina pachyderma* Ehrenb.					×	□
31. *Reophax cylindricus* Br.						×
32. *Saccorhiza ramosa* (Br.) var. *abyssalica* Z. Stschedrina						×
33. *Reophax guttifer* Br.						×
34. *Hormosina ovicula* Br.						×
35. *Haplophragmoides glomeratum* (Br.)						×
36. » *latidorsatum* (Br.)						○
37. *Trochammina globigeriniformis* (Park. et Jon.)						×
38. *Elphidium incertum* (Will.) var. *clavatum* Cushm.						△
39. *Pyrgo laevis* Defr.						△
40. *Pullenia sphaeroides* (d'Orb.)						×
41. *Eponides tenera* (Br.)						×
42. *Cibicides wuellersdorfi* (Schwag.)						×

Symbols: ○ — many, □ — mass, × — few, △ — usual.

the limits of the Arctic only in the Norwegian and the Greenland Seas. Not recorded in the Kara Sea.

The finding of *Pl. sphaera* in Shokalsky strait seems to be related to the penetration of Atlantic waters from the Polar basin by way of the western trough of the Laptev's Sea; this is in agreement with data obtained for other groups of animals ([1], [4]).

Summarizing all the aforesaid, we can draw the following conclusions: The basic nucleus of the foraminiferal fauna of the Kara Sea consists of several Arctic or cold water species more or less evenly distributed over the sea. Their distribution does scarcely depend on depth.

Various species join this nucleus in different parts of the sea; their distribution depends probably on a complex of factors of the habitat in a given region.

1. We find in the northern troughs representatives of the deep water Atlantic and Greenland fauna and boreal forms whose distribution is connected with the water flow of Atlantic origin.

2. In the south-eastern region the presence of the original fauna including several brack water types indicates the influence of a new strong factor, possibly, of the discharge of the Ob-Yenissei waters and of their deposits.

3. The occurrence of *Pl. sphaera* in the Shokalsky strait leads to suppose that there is a penetration of Atlantic waters by way of the Polar basin; the influence of these waters is felt also in the Vilkitzky strait and in the sea-region up to the Russkij Island.

Such is the scheme of distribution of foraminifera in the Kara Sea. Its general features are in agreement with the character of distribution of other groups of benthonic and planctonic animals. Therefore it is obvious that an analysis of the foraminiferal fauna will give a general idea of the basin which it inhabits, and that representatives of this fauna can serve as reliable indicators of the hydrological regime of any given habitat.

On account of their small size and strong shell they are well preserved in a fossil state and can be used in the reconstruction of the geological past of the recent seas.

Received
13. III. 1938.

REFERENCES

[1] Е. Гурьянова, Изв. Акад. Наук СССР (1936). [2] Г. П. Горбунов, Природа, № 5 (1937). [3] В. Л. Хмызникова, Исследование морей, вып. 24 (1936). [4] В. Л. Хмызникова, Тр. Арктич. ин-та, 82 (1937). [5] З. Г. Щедрина, Фонды Арктич. ин-та (1936, 1937).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

ZOOLOGY

NOTES ON THE ECOLOGY OF *DIPLOMESODON PULCHELLUM PULCHELLUM* LICHT. IN THE VOLGA-URAL SANDY REGIONS

By J. RALL

(Communicated by S. A. Zernov, Member of the Academy, 9. III. 1938)

Introduction. During the period of zoological explorations (1932—1937), conducted by members of the Saratov Microbiological and Epidemiological Institute in the sands of the Volga-Ural regions, interesting data were collected on ecology of a peculliar inhabitant of the sandy region—the piebald shrew or *Diplomesodon pulchellum pulchellum* Licht. Ever since very brief notes were published by Pallas and Eversmann, no further information has appeared in literature on the fundamental biological peculiarities of the *Diplomesodon pulchellum pulchellum* Licht. In general these shrews were considered to be very rare, and only a few specimens were exhibited in the collections of central museums.

Additional information about new collections of *Diplomesodon pulchellum pulchellum* Licht. in the sands between the Volga river and the Ural mountains, published by me in 1935 (1), justified the assertion that the Volga-Ural sands are inhabited by considerable quantities of *Diplomesodon pulchellum pulchellum* Licht. Within the period of 1934—1937, with the assistance of zoologists of the above mentioned Institute—M. P. Demyashov, M. V. Sheykina, J. M. Kazantzeva and the author—there were caught 89 *Diplomesodon pulchellum pulchellum* Licht., a number which far exceeds any collections of the particular shrew made heretofore.

Of this material a few carcasses were turned over to the collection of the Moscow Central Museum and were used by Prof. V. G. Geptner as an object of systematic studies.

Aside from gathering shrews, during the prolonged collection of food pellets of birds of prey in various spots of the Volga-Ural sand region, there were picked out a considerable number (about 200) of skull bones.

Ecological Notes. Of the total number of gathered *Diplomesodon pulchellum pulchellum* Licht., for various reasons only 71 were taken on record. These records have been used as the basis for my notes.

Quantity Fluctuations. In the Volga-Ural sands the *Diplomesodon pulchellum pulchellum* Licht., together with the *Crocidura suaveolens suaveolens* Pall. and the *Hemiechinus auritus* Gmel., constitute a relatively small group of the sand biocenosis. It has been noted that there exists a definite quantitative interrelationship between the various kinds of shrews, because all conditions of hunting being alike, those years which brought «a good crop» of one species, marked a poor harvest of the other.

	Annual catch of:			
	1934	1935	1936	1937
Diplomesodon pulchellum pulchellum Licht.	1	11	57	20
Crocidura suaveolens suaveolens	14	10	9	2

The conjecture suggested itself that the two species, having a great deal in common in their mode of life, are keen competitors, with unsteady quantitative interrelations.

It is rather difficult to ascertain the density of the *Diplomesodon pulchellum pulchellum* Licht. population in the sands. In the years, when they are most numerous, they number is not less than 1—2 to a hectare of hilly tracts. As far as the seasonal fluctuations in their numbers are concerned, owing to the limited material at hand, it may be stated that the gathering is at its highest in the spring.

The monthly catch of *Diplomesodon p. pulchellum* Licht. during 1934—1937

XII—II	III—V	VI—VIII	IX—XI
11	32	15	14

The *Diplomesodon pulchellum pulchellum* Licht. were caught in various ways: 43—by traps, 16—by deadfalls «Hero», 16—by snares, 1 was dug out, 2 were found dead and 2 were snapped away from a hen and a cat*.

Habitat and Hiding Places. Like all other animals of the sand steppes of the semi-desert type, shrews occupy all nooks of the variegated landscape, however, they mostly confine themselves to the hilly sands half-covered with vegetation, with damp cavities where sand has been driven away by the wind, with rich groups of *Elymus giganteus* and places densely overgrown with other typical sand plants. Out of the total of 71 *Diplomesodon pulchellum pulchellum* Licht. 63 were found in hilly sands, 6 in small sand-hillocks, half-covered with steppe vegetation, and 2 in yards adjacent to human dwellings. *Crocidura suaveolens suaveolens* Pall. likewise prefer hilly sands.

During the entire period of our works we tried to discover in the sands *Diplomesodon pulchellum pulchellum* burrows or other permanent dwelling places which would undoubtedly belong to these animals, but we did not succeed. Almost all of them were found among the numerous old burrows of *Pallosiomys meridianus* Pall. and *Meriones tamaricinus* Pall., sometimes in depressions under the groups of *Elymus giganteus*, under old stacks of threshed *Agriophyllum arenarium* and in similar hiding places. Most probably the *Diplomesodon pulchellum pulchellum* Licht. do not build shelters of their own and carry on a semi-migratory life.

From the information of D. Eropkin and our own findings, one may deduce that the shrews, just like other members of the family *Soricidae*, do not shun people's dwellings, being attracted by the domestic insects, food-supply and convenient loopholes.

Common Mode of Life. From the notes made by Eversmann who observed the *Diplomesodon pulchellum pulchellum* Licht. on the surface, one could already deduce that these shrews do not avoid day life. From our own experience we know cases when these animals were captured in the day time. However, the greatest number of *Diplomesodon pulchellum pulchellum* Licht. were caught between twilight and midnight.

Throughout the year the animals lead a very active and seemingly most individualistic life. They frequently change their dwelling places, utilizing

* Herein are presented data on 80 specimens of which we know how they were caught.

all the nooks in thickets, holes, stacks of *Agriophyllum arenarium* and buildings of men.

In captivity the *Diplomesodon pulchellum pulchellum* Licht., according to my observations and those of M. Sheykina, make the impression of pugnacious, vivid and voracious animals, fighting ferociously with their kin and with *Crocidura suaveolens suaveolens* Pall. They produce a peculiar sound which is louder and deeper than that produced by the *Crocidura suaveolens suaveolens* Pall.

Reproduction. As far as the reproduction of the *Diplomesodon pulchellum pulchellum* Licht. is concerned, there is but scant information available. Among the captured *Diplomesodon p. pulchellum* Licht., who were evidently sexually mature, there were 29 females of whom 10 were pregnant, 1 after a recent whelping, 10 were sterile, 8 had a indefinite generative system (for the uncertain state of the uterus and other reasons).

State of pregnancy					Number of embryos						
Months	IV	V	VI	VII	Number of embryos	3	4	5	6	7	*n* *M*
Number of cases . . .	1	2	3	4	Number of cases .	1	3	2	3	1	10 5.0

34 of the examined males showed a visible increase in the size of the testicles during the period from April to September. On August 9, 1937, incidentally, there were dug out from a shallow burrow, 30 cm deep, 4 young *Diplomesodon pulchellum pulchellum* Licht. lying in an old nest of a midday *(meridianus)*.

Therefore the reproduction period of the *Diplomesodon pulchellum pulchellum* Licht. lasts through April—August, whereby the females produce on the average 5 young in a litter and probably whelp more than once in a season, which is evidenced by the fact that the uterus of a pregnant female was still bearing visible traces of the last whelping.

It is doubtful whether the *Diplomesodon pulchellum pulchellum* Licht. produce offspring during the period from September to March, because of the absence of warm shelter for the young in the severe conditions of that period.

Some Miscellaneous Notes. Unfortunately, the sex of 8 *Diplomesodon pulchellum pulchellum* Licht. was not determined. Of the remaining 63 animals 34 were males and 29 females. After the animals were skinned, it became apparent that the females of the *Diplomesodon pulchellum pulchellum* Licht., notwithstanding their large size and the state of pregnancy, weighed less than the males, the latter being stouter. Thus, the average weight of the female was 10.7 g against 11.0 g of the male, while the average size of the female was L=70.1 mm, C=26.8 mm, and the size of male L=68.7 mm, C=26.3 mm. The average weight of a member of the population was 10.85 g.

It may be noted that the ratio $\frac{C}{L}$ % of the male is the same as that of the female *Diplomesodon pulchellum pulchellum* Licht., i. e. 38%. There were no other signs of sexual dimorphism noted.

The Closest Allies and Enemies. In the habitats which the *Diplomesodon pulchellum pulchellum* Licht. like most, they live in close contact with certain other inhabitants of the sands. The direct competitors of the *Diplomesodon pulchellum pulchellum* Licht. is *Crocidura suaveolens suaveolens* Pall. Of all other rodents, their closest neighbours are mice of the genus *Mus musculus wagneri* Eversm. and *Microtus arvalis* Pall.; *Pallasiomys meridianus* Pall. and *Meriones tamaricinus* Pall.; *Hemiechinus auritus* Gmel. and hamsters: *Cricetulus migratorius* Pall. and *Allocricetulus eversmanni* Br. The natural relationship between these animals and the *Diplomesodon pulchellum pulchellum* Licht. is not known.

According to our observations, the chief exterminator of the *Diplomesodon pulchellum pulchellum* Licht. in the sands are birds of prey, first of all the owl *Athene noctua*, other owls and perhaps *Burhinus oedicnemus*, who prey on all kinds of rodents.

Saratov State Institute
of Microbiology and Epidemiology.

Received
13. III. 1938.

REFERENCES

[1] J. R a l l, C. R. Acad. Sci. URSS, III (VIII), № 8 (68) (1935).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

ZOOLOGIE EXPÉRIMENTALE

EFFET DES INJECTIONS CRÂNIENNES DE SUSPENSION D'HYPOPHYSE CHEZ LEZ TÉLÉOSTÉENS

Par N. L. GERBILSKY

(Présenté par S. A. Zernov, de l'Académie, 13. III. 1938)

L'examen histologique de l'hypophyse des téléostéens *(Abramis brama, Lucioperca lucioperca, Perca fluviatilis, Leiocassis ussuriensis, Rhodeus amarus, Gasterasteus aculeatus, Cyprinus carpio, Salmo fario)* m'a permis d'établir que la neurocrinie hypophysaire, décrite dans ce groupe par Florentin (1), est au plus fort dans la péroide proche de la fraieson. Hormis le phénomène déjà signalé (1) de l'excrétion de colloide hypophysaire dans les racines du neurohypophyse et par cette voie dans le tuber cinereum et la cavité de l'infundibulum, j'ai pu établir que des masses considérables de secret—produit résultant du processus holocrine—se déversent à la surface de la glande, c'est-à-dire dans les espaces lymphatiques du crâne (2, 3). Nous désignerons cette voie d'excrétion comme craniocrinie hypophysaire.

Chez les téléostéens, dans la période de la ponte, l'hémocrinie n'est que peu considérable; elle est reléguée exclusivement au préhypophyse, lequel, chez les téléostéens, ne représente en volume qu'une partie minime de la glande.

Pendant la fraieson une forte hausse d'activité n'a lieu que dans la plus volumineuse partie de l'hypophyse (le lobe de transition et pars intermedia), c'est-à-dire dans les parties de la glande abondamment traversées par les racines du neurohypophyse. Les images morphologiques démontrant d'une manière frappante l'existence d'une corrélation fonctionnelle entre l'hypophyse et le système nerveux central, il était nécessaire d'obtenir une preuve expérimentale de ce que les substances gonadotropes de l'hypophyse et le système nerveux central dans leur interrelation ont une influence sur la ponte. En effet, l'injection d'une suspension d'hypophyse dans le crâne, dans les expériences avec l'éperlan, le sandre et la brème, fit que chez les femelles de ces espèces la fraieson fut accélérée de 25 à 35 jours par rapport à la période normale (2). Cet effet, c'est-à-dire le passage du IV au V stade de maturité*, fut obtenu par injection de doses relativement médiocres de suspension hypophysaire (dosage: deux glandes par femelle). Des injections intramusculaires ou intrapéritonéales de doses triplées ou quadruplées

* Dans l'ovaire correspondant au quatrième stade de maturation les oocytes ont déjà atteint leurs dimensions définitives, mais elles ne sont pas transparentes et sont rattachées l'une à l'autre par les éléments de nature épithéliale et conjonctive de l'ovaire. Le cinquième stade se distingue par la transparence da ses oocytes, par l'histolyse des éléments de rattache et par l'état coulant des oeufs mûrs.

de la même substance n'eurent aucun effet, non plus que des injections crâniennes d'une solution saline ou de suspension d'autres organes (muscles, foie).

Vu que l'effet obtenu se caractérise non pas par une stimulation de la croissance des oocytes, mais parce que l'organisme entre en fraieson et qu'il n'y a là que maturation finale des oocytes, lesquelles ont déjà atteint leurs dimensions définitives—le phénomène signalé doit être distingué de la stimulation normale de la maturation des individus non encore féconds. Quoiqu'il soit préférable de ne pas augmenter la terminologie endocrinologique, bien compliquée déjà, cependant, d'accord avec les traditions de cette science, il faudrait désigner l'agent actif de l'hypophyse dont nous nous occupons comme hormone de fraieson. Cette substance est à distinguer de l'hormone influençant la croissance des oocytes; ainsi le processus qu'il engendre doit être considéré séparément de l'activité générale gonadotrope de la glande pituitaire.

Subséquemment l'examen du fait signalé ci-dessus nous amena à reprendre ce problème dans les conditions de pêche industrielle. Une expédition fut organisée (personnel de l'expédition—N. L. Gerbilsky, L. A. Kachtenko et P. D. Kitchko). L'expédition travailla sous ma direction dans le delta du fleuve Don. Les expériences citées ci-dessous se rapportent à la période du 20. IV au 5. V 1937; lieu des expériences—station-observatoire de pisciculture à Rogojino au-dessus de Azov et du fleuve Bolchaya Kouterma.

D'après les données des spécialistes de pisciculture du fleuve Don, à la fin d'avril le pourcentage de maturation du sandre, les femelles étant mises à part pour buts de pisciculture selon la méthode usuelle, est de 10, tandis que pour la brème dans cette même période les femelles, conservées dans les vivières des stations de pisciculture, ne devinrent pas fécondes. Au mois de mai la maturation du sandre est de 25 à 30%; quant à la brème, conservée dans les vivières à cette même époque, les cas de maturation sont fort rares. En appliquant la technique des injections crâniennes nous avons obtenu 80% de maturation des femelles sandre au mois d'avril et pour les femelles brème, dans les mois d'avril et de mai, 60% (v. les données des tableaux 1 et 2).

Dans toutes les expériences citées ci-dessous la technique a toujours été la même. Ablation de l'hypophyse; trituration de la glande entre deux verres de montre dans une goutte de solution saline. Dilution de la suspension ainsi obtenue jusqu'à un volume de 0.5 cm^3. Chez la brème l'injection était faite par la fontanelle occipitale, chez le sandre par ponction de la portion mince de l'os occipital.

Dans les expériences de contrôle avec les mêmes volumes (injection de 0.5 cm^3 de solution saline) le pourcentage de maturation chez le sandre était tout au plus 8, chez la brème—0.

Ensuite nous avons pu établir expérimentalement l'existence d'une corrélation entre le temps nécessaire pous obtenir un certain effet et la température. Plus la température est basse, plus long est le temps qui s'écoule jusqu'à ce que l'effet se fait valoir (comp., par exemple, les données présentées dans les tableaux 1 et 3).

Il fut établi par les expériences subséquentes qu'une diminution de deux fois de la dose premièrement employée (deux glandes par femelle) n'abaisse pas l'effet; le temps écoulé et le pourcentage de maturation sont les mêmes.

Discussion

L'effet produit chez les téléostéens par le prolane et les substances gonadotropes de l'hypophyse sur l'entrée des poissons en fraieson a été signalé

Tableau 1

Sandre. Dosage: 2 hypophyses de femelles par femelle
(dans 0.5 cm³ de solution saline)

№ du poisson	№ de la corbeille	Date de l'injection	Date de l'ovulation
1	49	6 h. du soir 19.IV 1937	21.I 3 h. de l'après-midi
2	49	Dito	22—23.IV dans la nuit
3	49	»	23.IV 10 h. du matin
4	37	»	22—23.IV dans la nuit
5	37	»	23.IV 6 h. du soir
6	37	»	23.IV 6 h. du soir
7	48	»	22.IV—53.IV dans la nuit
8	48	»	22—23.IV » » »
9	48	»	22—23.IV » » »
10	48	»	22.IV 3 h. de l'après-midi

Température pendant l'expérience:

19.IV — 9.25°
20.IV — 11°
21.IV — 14°
22.IV — 12°
23.IV — 16°
} t° maximale

Résultats;

Pourcentage de maturation—100

Tableau 2

Brème. Dosage: 1 hypophyse de femelle par femelle
(dans 0.5 cm³ de solution saline)

№ du poisson	№ de la corbeille	Date de l'injection	Date de l'ovulation	Notes
1	35	26.IV au soir	27—28 dans la nuit	Effet obtenu approximativement 30 h. après l'injection
2	35	Dito	27—28 » » »	
3	35	»	27—28 » » »	
4	13	»	27—28 » » »	
5	13	»	27—28 » » »	
6	13	»	L'ovulation n'a pas eu lieu	
7	58	»	Dito	
8	58	»	27—28 dans la nuit	
9	58	»	27—28 » » »	
10	Placée dans la vivière	»	Morte	

Température pendant l'expérience:

26.IV—17.5°
27.IV—18°
28.IV—18°
} t° maximale

Résultats:

Pourcentage de maturation—70

par plusieurs auteurs ([4], [5], [6], [7]). Ainsi, par exemple, une injection intramusculaire d'énormes doses de prolane fit que, dans les conditions de laboratoire, une perche fraya en hiver ([4], [5]). Une autre fois une injection de doses énormes de prolane fit apparaître pour quelque temps l'ovipositor chez *Rhodeus amarus* sans modification des gonades. Le même effet, de pair avec

Tableau 3

Sandre. Dosage: 2 hypophyses de femelles par femelle

№ du poisson	№ de la corbeille	Date de l'injection	Date de la fraieson
1	35	28.IV au soir	28—29.IV dans la nuit
2	35	Dito	30.IV 4 h. du matin
3	35	»	29.IV au soir
4	54	»	29.V 10 h. du matin
5	54	»	Morte
6	54	»	30.IV 9 h. du matin
7	60	»	28—29.IV dans la nuit
8	60	»	29.IV 10 h. du soir
9	60	»	Morte

Température pendant l'expérience:

22.IV—16°
29.IV—20°
30.IV—18°

Résultats:

Pourcentage de maturation—77.7

une augmentation de 20 à 30% du poids de l'ovaire, a été obtenu chez *Rhodeus amarus* par des injections intrapéritonéales de doses énormes de substance hypophysaire de grenouille ou bovine (6).

Il a été possible de rendre fécondes des *Astinax teniatus* et *A. bimaculatus* par injection de «aceton powder», préparé des hypophyses des animaux de la même espèce (7).

Ce qu'il y a de frappant dans les travaux cités ce sont les doses énormes des préparations hormonales nécessaires pour obtenir un effet. Ceci ne concorde aucunement avec la notion qu'on se fait des hormones comme de substances de haut effet.

D'autre part, l'expérience dans les conditions de laboratoire, dans laquelle la température—ce puissant facteur de la maturation des poissons—n'a pas été prise en considération, est insuffisante: on ne peut en tirer des conclusions physiologiques convaincantes. Ceci explique aussi l'ineffectualité des efforts faits pour appliquer les injections du prolane et des produits hypophysaires dans les conditions industrielles.

Ces difficultés furent supprimées grâce aux recherches histologiques et aux expériences citées ci-dessus. Il fut établi qu'il existe une corrélation fonctionnelle profonde entre l'appareil humoral et le système nerveux dans leur action sur la fraieson, ce qui explique les doses énormes et l'imparfaite valeur de leur effet dans les injections intramusculaires et intrapéritonéales.

Emploi de la méthode d'injections crâniennes dans l'industrie

Dans l'industrie les méthodes d'injections crâniennes se font valoir en premier lieu par ce qu'elles permettent d'obtenir des oeufs fécondables pendant presque tout le temps que dure la pêche de l'espèce en question et non pas seulement pendant la fraieson normale du poisson; ensuite, leur emploi amène une hausse considérable du pourcentage de maturation parmi les poissons producteurs conservés dans les réserves. Donc, il est possible de dresser un programme de pisciculture et d'en rehausser la technique. Nous citons ici les données de Don-rybaksojuz pour la saison de pêche 1937.

Il y avait 8060 femelles de brème qui ont subi les injections. Le pourcentage de maturation obtenu était de 58.5 (1492 femelles de brème avaient été placées dans les vivières sans subir d'injections, on n'en obtint que 7.5% de poissons féconds). Certaines stations ont eu un pourcentage de maturation encore bien plus considérable, ainsi à la station de pisciculture à Rogojino (directeur I. L. Ivanov) la pratique des injections fit que des 1959 femelles placées dans les réserves 1440 devinrent fécondes.

En hiver 1934 nous avons tenu des cours organisés par Glavrybzavod et par Vsesojuz Rybakkolhozcentre, et nous y avons instruit les éleveurs des divers bassins de l'Union à l'emploi dans la pisciculture de la méthode des injections crâniennes.

Laboratoire de Biologie générale.
Université de Léningrad.

Manuscrit reçu
le 13. III. 1938.

LITTÉRATURE CITÉE

[1] Florentin, Rev. franç. d'endocr., 12, № 4 (1934). [2] Гербильский и Кащенко, Бюлл. экспер. биол. и мед., III, вып. 2 (1937). [3] Гербильский, Вестник. знания, № 7 (1937). [4] Скадовский и Парфенова, Уч. зап. МГУ, № 9 (1935). [5] Морозова, Зоол. журн., XV, вып. 1 (1936). [6] Артемов, Бюлл. экспер. биол. и мед., № 1 (1936). [7] Cardoso, Pereira, Ihering, Azevedo, Матер. XV междунар. физиолог. конгресса.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XIX, № 4

ZOOLOGIE EXPÉRIMENTALE

L'INFLUENCE DE L'AGENT GONADOTROPE DE L'HYPOPHYSE SUR L'ÉTAT DE LA FRAIESON CHEZ *L'ACIPENSER STELLATUS*

Par N. L. GERBILSKY

(Présenté par S. A. Zernov, de l'Académie, 13. III. 1938)

Jusqu'à nos jours l'endocrinologie expérimentale ne s'est occupée des ganoïdes qu'à un degré fort minime. Il n'existe, de ma connaissance, que deux ouvrages se rapportant à ce groupe: l'excellent—quant à la technique et aux résultats obtenus—travail de Zahl et Davis (1) qui servit à établir chez le ganoïde *Amia calva* l'existence des hormones sexuelles masculine et féminine, et les recherches de Skadovsky et Morozova (2) dont les auteurs, par injection de fortes doses de gravidane, ont obtenu chez l'esturgeon une fraieson abortive dans 20% de cas.

Cependant, au point de vue de la physiologie évolutive la régulation humorale chez les ganoïdes, ce groupe phylogénétiquement fort ancien et isolé présente un grand intérêt. Il était donc tout naturel que, après avoir établi l'existence d'une profonde corrélation entre la régulation humorale et la neurorégulation chez les téléostéens et l'élaboration des méthodes d'injections crâniennes pour accélérer le passage des poissons du stade IV au stade de fraieson (3, 4), nous fussions attirés à étudier les mêmes processus chez les ganoïdes. En même temps ces recherches étaient d'actualité pour la pisciculture pratique car jusqu'à nos jours les efforts faits pour conserver en vivières ou autrement les femelles des acipensérides jusqu'à leur entrée en fraieson ont été ineffectifs. Ainsi les possibilités de la culture des acipensérides étaient limitées à la capture de femelles fécondes près des frayères normales, une pratique qu'on ne peut considérer comme effective d'autant plus qu'un grand nombre de femelles pêchées au stade IV ne pouvaient être employées comme producteurs.

Dans l'article présent nous communiquons les résultats obtenus par l'expédition envoyée par l'Université d'État à Léningrad (personnel de l'expédition—N. L. Gerbilsky, I. D. Kitchkov et G. M. Persov). Cette expédition, placée sous ma direction, travailla du 15 juin au 10 août 1937 dans la région de la culture d'esturgeons à Kouban (Oust-Lobinskaya—Kadouchkino) et dans l'embouchure du fleuve Protoka (Atchouiev). Pour l'*A. stellatus* la technique de l'introduction de la substance hypophysaire diffère quelque peu de celle qui a été élaborée pour les téléostéens.

Pour l'ablation de l'hypophyse on ôtait avec un couteau tranchant la cuirasse extérieure osseuse de la tête et la portion pariétale du chondrocranium, on éloignait toute la masse cérébrale et là-dessus on extrayait l'hypophyse, presque toujours avec le tissu chondroïde ambiant, au moyen d'une

№	Date de l'injection	Date de l'ovulation	Notes
	Variante de dosage: deux hypophyses de mâles par femelle		
1	23.VII—18 h.	24.VII—18 h.	Les oeufs furent récoltés et fécondés
2	23.VII—18 h. 30 m.	24.VII—18 h.	La ponte des oeufs s'est produite normalement
3	23.VII—19 h.	24.VII—20—21 h.	Les oeufs furent récoltés et fécondés
4	24.VII—19 h.	—	Morte par suite de la destruction des vaisseaux bronchiaux. Les oeufs étaient détruits
5	25.VII—15 h.	—	Morte par suite de la destruction des vaisseaux bronchiaux. Les oeufs étaient détruits
6	25.VII—17 h.	26.VII—15 h. état initial de la fraieson	Les oeufs étaient détruits
7	26.VII—9 h.	27.VII—8 h.	La ponte des oeufs s'est produite normalement
8	26.VII—9 h. 30 m.	27.VII—9 h.	Les oeufs furent récoltés et fécondés
9	26.VII—8 h. 30 m.	27.VII—9 h.	Les oeufs furent récoltés et fécondés
10	26.VII—13 h. 30 m.	—	Morte (ventre dur)
11	26.VII—19 h.	27.VII—11 h.	Les oeufs furent récoltés et fécondés
12	26.VII—19 h. 20 m.	27.VII—14 h.	Les oeufs furent récoltés et fécondés
13	27.VII—15 h.	—	Morte bientôt après l'injection
14	9.VIII—15 h.	10.VIII—12 h.	Les oeufs furent récoltés et fécondés
	Variante de dosage: hypophyse d'un mâle par femelle		
15	26.VII—14 h.	27.VII—11 h.	Les oeufs furent récoltés et fécondés
16	27.VII—18 h.	28.VII—10 h. 30 m.	Les oeufs furent récoltés et fécondés
17	29.VII—11 h.	—	Les oeufs étaient détruits
18	30.VII—8 h.	30.VII—14 h.	Les oeufs furent récoltés et fécondés
19	31.VII—18 h.	—	Morte

Température pendant l'expérience 23—25°.

Résultats: Nombre de femelles devenues fécondes: 12;
» » » mortes mais présentant certains caractères de maturation—4;
3 femelles périrent.

lance courbe (instrument dont se servent les dentistes pour ôter le calcul dental). Le tissu chondroïde éloigné, on triturait les glandes entre deux verres de montre et on obtenait une fine suspension homogène. La suspension était additionnée de solution saline pour obtenir un volume de 1 cm³. On aspirait le liquide dans une seringue. Les injections étaient faites avec les aiguilles de Lumbal ou de Bier, employées dans la médecine et la vétérinarie pour les ponctions spinales. On introduisait l'aiguille dans le crâne en la faisant traverser le derme et les muscles du dos et puis l'épaisse couche du tissu chondroïde du crâne, la tige, dont ces aiguilles sont munies, les préservant de l'occlusion. Là-dessus on éloignait la tige et on introduisait le bout

de la seringue contenant le liquide dans le pavillon de l'aiguille, puis on faisait l'injection. Pendant toute la durée de l'opération le poisson restait toujours dans l'eau, on ne faisait que le remonter pour avoir au-dessus de la surface de l'eau l'endroit de la tête de l'animal choisi pour faire les injections. En procédant de cette manière, nous n'avons jamais eu de perte de poissons pendant l'injection. Comme il n'y avait aucune installation pour conserver les femelles en expérience nous étions obligés de les tenir «au koukane», c'est-à-dire attachées à une corde.

Dans le cours moyen de Kouban l'expédition dans cette période obtenait en moyenne 14 mâles sur une femelle, il était donc tout indiqué d'employer les mâles comme «donneurs». Cette modification involontaire de notre technique nous permit d'établir le fait que l'agent gonadotrope de l'hypophyse chez les *A. stellatus* est sexuellement non spécifique. Les expériences instituées démontrèrent (v. tableau) que les injections ont un effet hautement positif.

Les femelles pêchées près des frayères étaient «dures» (stade IV), elles produisaient des oeufs fécondables en moyenne 24 heures après avoir subi l'injection crânienne. Bientôt après l'injection (quelques heures) ces femelles commençaient à se comporter d'une manière fort tempêtueuse. Habituellement tranquille et même lent lorsqu'il est tenu «au koukane», le poisson sortait de l'eau par soubresauts, tirait sur son attache et blessait avec ses écussons ceux qui vérifiaient les résultats d'expérience. C'est à ce comportement du poisson qu'est dû le nombre considérable de cas de perte caractérisés par les mots: «morts, présentant certains caractères de maturation». On trouvait chez ces individus tous les symptômes de maturation: ventre mou, concentration de la masse des oeufs dans la partie postérieure de la cavité abdominale lorsque le poisson était placé en position verticale, coloration rouge de la partie postérieure du ventre. Mais le frai obtenu était non fécondable. Quelques-uns des poissons périrent ou furent gravement blessés. Cela va sans dire que ces échecs par lesquels l'effet industriel des injections se trouve considérablement réduit peuvent être évités par l'amélioration des conditions, dans lesquels les femelles en expérience doivent être conservées.

L'éclosion des oeufs obtenus des femelles en expérience se produit normalement. Le développement des jeunes poissons, tenus sous observation par les spécialistes de pisciculture G. J. Dorochin et F. F. Iolkin jusqu'au mois d'octobre, avait également un cours tout-à-fait normal.

Ayant obtenu des résultats positifs dans les localités voisines des frayères nous entreprîmes des recherches sur la possibilité d'obtenir le même effet dans la région de l'embouchure du fleuve, c'est-à-dire où a lieu la grande pêche industrielle de l'*A. stellatus*. Tel est, à Kouban, le point principal de pêche industrielle—Atchouiev; la pêche s'y fait dans le bas de la rivière Protoka. Les expériences instituées pour faire atteindre aux femelles l'état de l'ovulation concordent pleinement, par leurs résultats, avec les résultats obtenus dans le cours moyen de Kouban que nous venons de décrire. Au mois d'août, dans la région de Atchouiev, on ne pêchait qu'un mâle sur 10—15 femelles. Il fallait donc, contrairement à la pratique de Kouban, employer les hypophyses de femelles et non de mâles.

Le frai obtenu à Atchouiev, c'est-à-dire dans la région immédiatement attenant à la mer, à une distance de 400 à 500 kilomètres des frayères, était selon toute apparance complètement normal, mais l'éclosion des oeufs s'arrêtait au stade de 4 ou 8 blastomères ce que nous sommes enclins de mettre au compte du régime hydrologique qu'on trouve dans l'embouchure du fleuve et qui diffère fortement de celui du cours moyen de Kouban, où le fleuve retient encore en grande partie le caractère d'un fleuve de montagne.

En fait de contrôle nous avons employé dans ces expériences l'injection d'un même volume de solution saline, resp. de solution de prolane cristalline dans la proportion de 150—300 M. E. par femelle. Dans aucun de ces 15 cas il n'y eut de maturation.

La corrélation excessivement étroite entre la régulation humorale et la neurorégulation de la fraieson, que nous avons précédemment constatée chez les téléostéens, se fait valoir également chez les ganoïdes.

Le fait que nous avons pu obtenir des oeufs fécondables des femelles pêchées à une distance de 1½ à 2 kilomètres de la mer, peut servir d'argument contre l'opinion usuelle des ichtyologues que, relativement à la maturation des produits sexuels, la résistance à la pression du courant d'eau représente un facteur de prime importance chez les poissons migrateurs.

Les expériences que nous avons instituées dans le cours moyen de Kouban, ont fait que les stations de pisciculture de Kouban ont à présent la possibilité d'obtenir le frai des femelles pêchées au stade IV, tandis que précédemment ces stades ne pouvaient être employés comme producteurs.

Laboratoire d'histologie physiologique.
Université d'Etat à Léningrad.

Manuscrit reçu
le 13. III. 1938.

LITTÉRATURE CITÉE

[1] Zahl and Davis, Journ. of Exp. Zool., 63, № 2 (1932). [2] Скадовский, Ученые зап. МГУ, № 8 (1936). [3] Гербильский, Вестник знания, № 7 (1937). [4] Гербильский и Кащенко, Бюлл. экспер. биол. и мед., III, вып. 2 (1937).

ERRATA

1) In the article by N. Nekrasov (N. Nekrassow), XVIII, № 7, p. 444 the first sentence of the last paragraph should read as follows: «The above conclusions comprise not only irreversible redox-systems».

2) In the article by Dontcho Kostoff (1938, XVIII, № 7, p. 461) in column II of the table to be read 33 instead of 35.

PRIX D'ABONNEMENT

Un an — 36 livraisons . . . . $ 12.00. Frs. fr. 250.00. £ 2.8.0
Six mois — 18 livraisons . . . $ 6.00. Frs. fr. 125.00. £ 1.4.0
(Séparément $ 0.40. Frs. fr. 8.00. £ 0.1.6 le numéro)

URSS — MEZDUNARODNAJA KNIGA, 18, Kuznetskij Most, Moscou (Compte courant n° 263 Banque d'Etat de l'URSS, 12, Neglinnaja, Moscou).
U. S. A., NORTH and SOUTH AMERICA — BOOKNIGA CORPORATION. 255 Fifth Avenue. New York, N. Y.
ENGLAND — W. H. SMITH & son, Ltd. Strand House, Portugal Str. London W. C. 2.
COLLET'S Foreign Department. 31 Gerrard Street, London W. I.
FRANCE — MESSAGERIES HACHETTE. Service Abonnements. 111, Rue Réaumur. Paris, 2e.
SUISSE — Buchhandlung STAUFFACHER (Genossenschaft). Hauptpost-Fach 43. Zürich.
ESPANA — „DISTRIBUIDORA DE PUBLICACIONES". Diputacion, 260. Barcelona.
Č. S. R. — MELANTRICH, Akc. Spol. Knihkupectví — odd. slovanských knih. Václavské nám 42. Praha II. (Účet pošt. spoř. 20. 208).
BELGIQUE — OBLA (Office Belge Littéraire et Artistique). 6/8/10, rue Duquesnoy. Bruxelles.
LIETUVA — „MOKSLAS". Knygynas. Laisves Aleja, 46. Kaunas.
— SPAUDOS FONDAS. Laisves Al. 62. Kaunas.
TURQUIE — LIBRAIRIE HACHETTE. Succursale de Turquie. 469, Avenue de l'Indépendance. Boite Postale Pera 2219. Istanbul.
DEUTSCHLAND — KOEHLER & VOLCKMAR, A/G. Russland-Abteilung. Postfach 173. Leipzig C. I.
POLSKA — GEBETHNER & WOLFF. Filja I. Krakowskie Przedm. 15. Warszawa.
ROSSICA. Chmielna 5. Warszawa.
PALESTINE — SAFRAN CO. Jaffa Rd. 36. P. O. B. 223. Haifa.
LATVIJA — VALTERS un RAPA Akc. Sab. Teatra iela II. Riga (Pasta tek. rek. № 675).
K/s „LAIKMETS". Terbatas iela 37. Riga.
SVERIGE — C. E. FRITZE's Kgl. Hofbuchhandlung. Fredsgatan 2, Stockholm.
A. B. WENNERCRENS WIILIAMS Box 657, Stockholm I.
AUSTRALIA — MODERN PUBLISHERS Ltd., 124 Oxford Street. Sydney.
BULGARIA — T. F. TSCHIPEFF. Buchhandlung Boulevard Dondoukoff 20/22 Sofia. (Postscheckkonto-Sofia, 540).
NORGE — JOHAN GRUNDT TANUM. Tidligere Aschehougs Boghandel. Karl Johans gt. 43. Oslo.
ROMANIA — Biroul Central de Presa „LUVRU". Strada Oituz, 14, Bucuresti I.
EESTI — TÖÖKÖÖL, Pärnu mnt. 28, Tallinn.
DÄNEMARK — S. U. V. s Boghandel. Frederiksbarggade 42¹. Kopenhagen. K.

Les «Comptes Rendus», largement expédiés à l'étranger dans les centres scientifiques les plus importants et dans les bureaux de nombreuses revues, sont le seul organe scientifique en URSS, donnant tous les dix jours un compte rendu des plus récentes acquisitions de la science soviétique.

Prix $ 0.50